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AN APPARENT INFLUENCE OF THE EARTH ON SOLAR PROMINENCES

BY J. EVERSHED, F.R.S., and P. R. CHIDAMBARA AYYAR, B.A.[1]

In her well-known paper on "An Apparent Influence of the Earth on the number and area of Sunspots in the Cycle 1889--1901," Mrs. Maunder gives evidence which "seems to show that spots tend to diminish in area rather than to increase as they pass under the Earth, and that there is a decided tendency to check the generation of spots on the hemisphere presented to the Earth."[2]

In Kodaikanal Bulletin No. XXVIII "On the Relative Numbers of Prominences observed on the Eastern and Western Limbs," the evidence given seems to support the conclusion that in the case of prominences also there is a tendency to a diminution in numbers as they cross the visible disc.

On the other hand, Dr. Royds and S. Sitarama Ayyar have shown by the periodogram method of Schuster that any effect due to planetary action, including the Earth, is improbable, although "the observed systematic excess on the one limb or any periodicities in its variations must be associated with the Earth's direction."[3]

If it is assumed that the Earth tends to extinguish a prominence during its passage across the Sun's disc, this action might be expected to vary between the northern and southern hemispheres having some relation to the direction of the Earth or to the relative areas presented to the Earth. For instance, between February and March of each year the centre of the Sun's disc is in 7° south latitude and the total visible area of the southern hemisphere is greater than that of the northern by about 28 per cent. In August and September the northern hemisphere predominates over the southern by the same amount. If therefore the Earth really exerts an influence on the prominences, this difference in area or the change in the direction should give rise to a semi-annual periodicity in the eastern excess for each hemisphere. The Sun's synodic rotation period being roughly 28 days, we can find the amount of extinction supposed to be produced by the Earth by comparing the prominences on any day on the east limb with those on the west limb fourteen days later. Thus, if x be the prominences reckoned in numbers or areas observed on the east limb on the first day, y those observed on the west limb on the 15th day, the extinction is $x - y = E$, where E may be expressed as a percentage of x, and is positive when prominences are reduced in number or area, negative when new prominences are added or areas increased.

Let us suppose that the inclination of the Sun's axis, which we call D, is a maximum in the north, or $D = +7°$. Then $x_n - y_n = E_n$ will represent the extinction in the northern hemisphere, where x_n represents the prominences observed on the north-east limb on any day, and y_n those observed on the north-west limb on the fifteenth day. Similarly $x_s - y_s = E_s$ will represent the extinction in the southern hemisphere. But since the northern hemisphere is presented towards Earth, E_n should be greater than E_s, $E_n - E_s$ being positive.

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[1] Mr. Chidambara Ayyar who recently joined the staff at Kodaikanal has by great industry in dealing with the mass of material contained in our prominence records discovered a new relation between prominence frequencies east and west of the sun's axis and the heliographic latitude of the Earth. This, while adding weight to the case for an influence of the Earth on solar phenomena, is apparently opposed to the suggestion that the Earth tends to extinguish a prominence in its passage across the visible disc. Mr. Chidambara Ayyar is entirely responsible for the method of treating the records and for the facts given in this paper, and is to be congratulated on the interesting and suggestive results of his research.--J.E.

[2] Monthly Notices of the Royal Astronomical Society, LXVII, 474.

[3] Kodaikanal Observatory Bulletin No. XXXV.

In the same way, when D is $-7°$, E_s should be greater than E_n, $E_n - E_s$ being negative. If therefore our assumption is correct, the value of $E_n - E_s$ should every year be positive when $D = +7°$ and negative when $D = -7°$, or at any rate the values should rise and fall consistently with the changes in D.

If on the other hand $E_n - E_s$ is systematically negative when $D = +7°$, and positive when $D = -7°$, or the value falls for $+7°$ and rises for $-7°$, it would seem that the Earth instead of extinguishing prominences tends to sustain or generate them.

This principle has been employed in examining the large amount of material supplied by the prominence records of the Kodaikanal Observatory for the years 1904—1920. Precautions have been taken to ensure trustworthy comparisons of the east and west limbs on pairs of days a fortnight apart. For example, if prominences were recorded on a fine day and the record for the fifteenth day was imperfect in any way, the comparison would show an exaggerated extinction, but the extinction would be lessened if the conditions existed in the reverse order. It was therefore necessary to reject all pairs of days on which complete records did not exist, or the photographs were not obtained under as far as possible ideal conditions.

The comparisons have been made in the first instance at epochs when the value of D reaches 7° or over, north and south, which limits the number of days in each year to 30 pairs between February and March and 30 pairs between August and September, and since a proportion of these has to be rejected, the material for each individual year becomes too slender to indicate any very trustworthy result. It is indeed surprising that the annual results come out as consistently as they do.

Table I gives the results of examining in this way the prominence numbers for the entire period of 16 years 1904—1920. Owing to the much more favourable conditions in February and March compared with August and September, when cloudy monsoon weather prevails, the annual numbers for $D = -7°$ are much larger and therefore give more trustworthy mean values than those for $D = +7°$.

It will be seen that the percentage of extinction on the west limb varies very irregularly, as is to be expected in dealing with such relatively small numbers for each year. Yet there is seen to be more often a gain than a loss of prominences on the west limb in that hemisphere which is turned towards Earth, and when we compare the values $E_n - E_s$ for $D = +7°$ with those for $D = -7°$ there results a systematic difference, which is readily appreciated when the values are plotted as we have done in diagram No. I. Here it is evident that whilst the values rise and fall with respect to the zero line of no difference in extinction, yet the higher points are consistently at $-7°$ and the lower at $+7°$ for every year until 1916 or 1917, when a change occurs, and from 1917 onwards the reverse is the case, the + values of D corresponding with the greater extinction in the north. It is to be noted that this change occurs at a time when the general distribution of prominences between east and west underwent a marked change. Thus from the beginning of our records in 1905 until the end of 1916 each year has shown a numerical excess of eastern prominences, excepting 1914, when there was a very slight western excess. The proportion of eastern prominences averaged 52·7 per cent of the whole number from 1905 to 1911 inclusive, and in the five years 1912—1916 it was 50·5 per cent only. Between 1916 and 1917 it fell from 50·5 to 49·5 per cent, and in the four years 1917—1920 the mean is 48·2 per cent.

If we take areas instead of numbers the same change is exhibited, both in the general distribution between east and west and in the periodical relation between the northern and southern hemispheres corresponding to the extreme values of D plus and minus. But the figures for prominence areas show smaller departures from equality between east and west than do numbers. The mean eastern proportion for the five years 1912—1916 for areas is 50·2 per cent instead of 50·5 per cent for numbers, and for the four years 1917—1920 it is 49·0 per cent instead of 48·2 per cent.

We have tabulated in the same way as for numbers the areas of prominences for the epochs when D has the extreme values of $+7°$ and $-7°$, but in this case we start with 1910, since estimates of areas are not available before that date. The results are shown in Table II, the unit in this case is a tenth of a square minute of arc. The same apparently unsystematic irregularities are even more marked than in the case of

numbers, yet the comparison of the values $E_n - E_s$ for $D = +7°$ and $D = -7°$ shows the same periodical fluctuations, in which plus values (representing a greater extinction in the northern hemisphere) or the higher points in the curve occur when $D = -7°$. There is also the same change of sign between the years 1916 and 1917, after which the higher points correspond to $D = +7°$. The results are plotted in diagram No. II.

So far we have taken no account of the intermediate values of D. In order to determine whether the value $E_n - E_s$ rose and fell in the negative direction concurrently with the increase and decrease in D, and vice versa, it was necessary to examine the prominences of every day from the first week in June 1904 to the first week in June 1920, throughout each of the years, and tabulate the numbers east and west by the method already described. This was a most laborious undertaking, but the results obtained have, we think, justified the labour spent upon it.

The change in D was divided into a series of stages as follows :—0° to 2°, 2° to 4°, 4° to 6°, 6° to 7°, 7° to 6° and so on in the reverse order. The extinction was then calculated on those prominences that started from the east limb during the period that D was changing from 0° to 2°, from 2° to 4°, and so on. The values of $E_n - E_s$ for each such stage and for all the years is given in Table III. The mean values for the 16 years have been plotted in diagram No. III. This result is most striking, the curve being a fair approximation to the ideal sine curve that we might expect to get were the conditions perfect. There is a slight difference in phase in that the transition from positive to negative direction, and negative to positive, does not take place exactly at the point where $D = 0°$, and the maximum of the curve for the negative values of D does not occur exactly at $D = -7°$. This is possibly due to the inherent irregularities in the materials we are dealing with. It appears to us that the general trend of the curve shows that there is a close correlation between the variations in the proportion of eastern and western prominences and the heliographic latitude of the Earth.

The relation does not, however, appear to be a permanent one and applies only to the period 1904—1916 inclusive. If we take the years before and after the change which took place in 1916–1917 and plot the results in the same way we get the curves I and II in diagram No. IV. Here curve I is for the years 1904—1916 inclusive and curve II for the four years 1917—1920. It will be seen that whilst curve I approximates to the sine curve given in broken lines, curve II shows no relation at all to the values of D.

Finally we have investigated the relative frequencies between the northern and southern hemispheres to see whether any relation can be made out between the total activity of the hemisphere turned towards Earth compared with that turned away from Earth. Taking as before the epochs when D has the maximum values $+ 7°$ and $-7°$ we find that there is no such relation as is shown by the figures for the relative extinction between north and south.

On the whole during the period 1904—1920 there is shown a general preponderance of south over north the northern prominences being 48·1 per cent of the whole number when $D = +7°$ and 48·9 per cent when $D = -7°$. If we limit the period to 1904—1916 the figures are 48·1 and 48·2 per cent respectively. We can scarcely attach any significance to so small a difference as is here indicated.

THE OBSERVATORY, KODAIKANAL,
19th June 1921.

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TABLE I.

$D = +7°$.

Years.	North. Number of prominences on N.E. limb.	North. Number of prominences on N.W. limb.	North. Number of prominences extinguished.	North. Percentage of extinction or E_n.	South. Number of prominences on S.E. limb.	South. Number of prominences on S.W. limb.	South. Number of prominences extinguished.	South. Percentage of extinction or E_s.	$E_n - E_s$.
1904	18	34	− 16	− 88·9	40	23	+ 17	+ 42·5	− 131·4
1905	31	40	− 9	− 29·0	76	40	+ 36	+ 47·4	− 76·4
1906	46	54	− 8	− 17·4	68	43	+ 25	+ 36·8	− 54·2
1907	57	108	− 51	− 89·5	126	96	+ 30	+ 23·8	− 113·3
1908	58	63	− 5	− 8·6	100	74	+ 26	+ 26·0	− 34·6
1909	56	56	0	0	62	34	+ 28	+ 45·2	− 45·2
1910	52	66	− 14	− 26·9	60	58	+ 2	+ 3·3	− 30·2
1911	66	65	+ 1	+ 1·5	77	68	+ 9	+ 11·7	− 10·2
1912	61	60	+ 1	+ 1·6	78	71	+ 7	+ 9·0	− 7·4
1913	41	67	− 26	− 63·4	60	48	+ 12	+ 20·0	− 83·4
1914	66	46	+ 20	+ 30·3	74	50	+ 24	+ 32·4	− 2·1
1915	30	28	+ 2	+ 6·7	36	32	+ 4	+ 11·1	− 4·4
1916	49	55	− 6	− 12·2	59	42	+ 17	+ 28·8	− 41·0
1917	73	68	+ 5	+ 6·8	61	58	+ 3	+ 4·9	+ 1·9
1918	44	26	+ 18	+ 40·9	59	52	+ 7	+ 11·9	+ 29·0
1919	22	31	− 9	− 40·9	15	27	− 12	− 80·0	+ 39·1
Total and mean percentage.	770	867	− 97	− 12·6	1,051	816	+ 235	+ 22·4	− 35·0

$D = -7°$.

Years.	North. Number of prominences on N.E. limb.	North. Number of prominences on N.W. limb.	North. Number of prominences extinguished.	North. Percentage of extinction or E_n.	South. Number of prominences on S.E. limb.	South. Number of prominences on S.W. limb.	South. Number of prominences extinguished.	South. Percentage of extinction or E_s.	$E_n - E_s$.
1905	193	99	+ 94	+ 48·7	143	189	− 46	− 32·2	+ 80·9
1906	147	150	− 3	− 2·0	132	142	− 10	− 7·6	+ 5·6
1907	240	126	+ 114	+ 47·5	213	219	− 6	− 2·8	+ 50·3
1908	163	91	+ 72	+ 44·2	114	160	− 46	− 40·4	+ 84·6
1909	125	119	+ 6	+ 4·8	149	149	0	0	+ 4·8
1910	149	130	+ 19	+ 12·8	127	129	− 2	− 1·6	+ 14·4
1911	146	133	+ 13	+ 8·9	158	148	+ 10	+ 6·3	+ 2·6
1912	113	101	+ 12	+ 10·6	128	122	+ 6	+ 4·7	+ 5·9
1913	133	132	+ 1	+ 0·8	134	127	+ 7	+ 5·2	− 4·4
1914	150	114	+ 36	+ 24·0	117	125	− 8	− 6·8	+ 30·8
1915	160	192	− 32	− 20·0	162	194	− 32	− 19·8	− 0·2
1916	139	150	− 11	− 7·9	172	174	− 2	− 1·2	− 6·7
1917	222	182	+ 40	+ 18·0	171	191	− 20	− 11·7	+ 29·7
1918	161	146	+ 15	+ 9·3	151	150	+ 1	+ 0·7	+ 8·6
1919	114	100	+ 14	+ 12·3	113	113	0	0	+ 12·3
1920	84	87	− 3	− 3·6	73	78	− 5	− 6·4	+ 2·8
Total and mean percentage.	2,439	2,052	+ 387	+ 15·9	2,257	2,410	− 153	− 6·8	+ 22·7

TABLE II.

Year.	$D=-7°$. North. Prominences N.E.	$D=-7°$. North. Prominences N.W.	$D=-7°$. North. Prominences extinguished.	$D=-7°$. North. Percentage of extinction or E_n.	$D=-7°$. South. Prominences S.E.	$D=-7°$. South. Prominences S.W.	$D=-7°$. South. Prominences extinguished.	$D=-7°$. South. Percentage of extinction or E_s.	E_n-E_s.	$D=+7°$. North. Prominences N.E.	$D=+7°$. North. Prominences N.W.	$D=+7°$. North. Prominences extinguished.	$D=+7°$. North. Percentage of extinction or E_n.	$D=+7°$. South. Prominences S.E.	$D=+7°$. South. Prominences S.W.	$D=+7°$. South. Prominences extinguished.	$D=+7°$. South. Percentage of extinction or E_s	E_n-E_s.
1910	313·5	219·0	+ 94·5	+ 30·1	213·0	253·0	− 40·0	− 18·8	+ 48·9	38·0	56·5	− 18·5	− 48·7	63·5	62·0	+ 1·5	+ 2·4	− 51·1
1911	172·0	164·5	+ 7·5	+ 4·4	210·5	200·0	+ 10·5	+ 5·0	− 0·6	70·0	78·5	− 8·5	− 12·1	136·0	98·5	+ 37·5	+ 27·6	− 39·7
1912	102·0	121·0	− 19·0	− 18·6	197·5	137·0	+ 60·5	+ 30·6	− 49·2	50·0	66·5	− 16·5	− 33·0	136·0	99·5	+ 36·5	+ 26·8	− 59·8
1913	152·0	169·5	− 17·5	− 11·5	125·5	117·5	+ 8·0	+ 6·4	− 17·9	45·0	50·0	− 5·0	− 11·1	116·5	75·0	+ 41·5	+ 35·6	− 46·7
1914	187·0	105·5	+ 81·5	+ 43·6	83·0	101·0	− 18·0	− 21·7	+ 65·3	107·0	24·0	+ 83·0	+ 77·6	104·0	56·0	+ 48·0	+ 46·2	+ 31·4
1915	206·5	340·0	− 133·5	− 64·6	172·0	368·0	− 196·0	− 114·0	+ 49·4	50·0	44·0	+ 6·0	+ 12·0	98·5	127·0	− 28·5	− 28·9	+ 40·9
1916	349·0	152·5	+ 196·5	+ 56·3	232·5	200·0	+ 32·5	+ 14·0	+ 42·3	112·0	59·0	+ 53·0	+ 47·3	93·0	72·0	+ 21·0	+ 22·6	+ 24·7
1917	445·0	401·0	+ 44·0	+ 9·9	471·0	447·5	+ 23·5	+ 5·0	+ 4·9	54·0	54·5	− 0·5	− 0·9	93·5	107·0	− 13·5	− 14·4	+ 13·5
1918	280·0	407·0	− 127·0	− 45·4	322·5	386·5	− 64·0	− 19·8	− 25·6	98·5	65·0	+ 33·5	+ 34·0	204·0	94·5	+ 109·5	+ 53·7	− 19·7
1919	245·0	249·5	− 4·5	− 1·8	375·5	239·5	+ 136·0	+ 36·2	− 38·0	59·5	68·5	− 9·0	− 15·1	19·0	18·5	+ 0·5	+ 2·6	− 17·7
1920	205·0	344·5	− 139·5	− 68·0	270·5	280·5	− 10·0	− 3·7	− 64·3	159·0	185·0	− 26·0	− 16·4	136·5	189·5	− 53·0	− 38·8	+ 22·4

TABLE III.

The value of $E_n - E_s$ as the value of D changes from 0° through +7° to 0° and from 0° through −7° to 0° for the years 1904–1905 to 1919–1920.

Years.	0° to 2°	2° to 4°	4° to 6°	6° to 7°	+7°	7° to 6°	6° to 4°	4° to 2°	2° to 0°	0° to −2°	−2° to −4°	−4° to −6°	−6° to −7°	−7°	−7° to −6°	−6° to −4°	−4° to −2°	−2° to 0°
1904–05	− 50·0	+ 10·1	− 13·4	− 88·7	−131·4	− 40·9	−170·1	− 85·0	− 86·8	− 53·1	− 25·9	− 16·7	+ 76·4	+ 80·9	+ 55·9	+ 57·8	+ 40·0	− 17·5
1905–06	+ 34·3	− 7·3	− 47·8	− 97·1	− 76·4	− 15·0	− 36·8	−133·3	− 22·2	− 34·0	− 10·3	− 15·7	− 9·9	+ 5·6	+ 93·4	+ 9·7	+ 13·6	+ 1·7
1906–07	− 23·9	+ 28·9	− 48·4	+ 7·6	− 54·2	− 27·8	− 96·9	− 39·6	− 18·4	− 39·5	+ 24·8	+ 20·1	+ 59·0	+ 50·3	+ 35·6	+ 10·3	+ 32·7	+ 49·7
1907–08	+ 69·8	+ 50·0	+ 28·5	− 58·6	−113·3	− 89·2	−103·1	− 50·2	− 62·4	− 21·0	− 2·3	+ 35·8	+ 51·4	+ 84·6	+ 80·3	+ 66·2	+ 40·0	− 18·4
1908–09	+ 31·0	− 1·1	− 33·1	+ 33·1	− 34·6	·0	− 10·8	− 6·8	− 6·5	− 2·7	− 10·8	+ 3·7	+ 53·1	+ 4·8	+ 2·6	+ 42·0	+ 22·7	+ 2·7
1909–10	+ 26·2	− 52·4	− 32·6	+ 42·4	− 45·2	+ 0·9	− 19·1	− 6·6	− 6·3	− 10·3	+ 38·8	− 0·9	− 18·5	+ 14·4	+ 29·7	+ 22·6	+ 4·2	− 9·6
1910–11	− 13·2	− 46·3	+ 0·2	+ 3·8	− 30·2	+ 9·7	− 13·6	− 26·1	+ 1·9	+ 28·2	+ 34·3	+ 15·6	+ 16·4	+ 2·6	+ 28·1	+ 35·0	+ 33·2	− 23·4
1911–12	+ 20·9	+135·0	+ 8·3	+ 12·3	− 10·2	+ 3·4	− 23·3	+ 1·5	+ 35·7	− 34·7	+ 5·5	+ 29·8	+ 32·5	+ 5·9	+ 25·0	+ 33·5	+ 6·8	+ 12·5
1912–13	− 3·2	− 6·8	+ 5·3	+ 37·3	− 7·4	− 19·1	+ 8·7	− 80·1	+ 32·1	+ 8·7	− 27·1	+ 21·9	+ 20·3	+ 4·4	+ 8·9	+ 35·2	+ 11·3	+ 1·0
1913–14	+ 32·3	− 47·1	+ 7·0	− 49·1	− 83·4	− 53·5	− 59·6	+ 40·4	− 12·6	+ 1·8	+ 1·7	+ 29·0	+ 38·0	+ 30·8	+ 42·1	+ 24·2	+ 42·3	+ 64·0
1914–15	+ 29·6	− 44·9	− 33·4	− 43·0	− 2·1	+ 27·4	+ 33·9	+ 1·1	− 47·3	− 7·1	+ 53·3	+ 50·4	+ 22·5	− 0·2	+ 12·7	+ 10·8	+ 35·0	+ 26·4
1915–16	− 26·9	+131·0	− 37·5	− 79·0	− 4·4	− 9·1	+ 4·9	− 19·0	+ 36·5	+ 12·0	− 2·5	− 2·8	+ 18·5	− 6·7	+ 20·6	+ 11·8	− 10·5	− 10·3
1916–17	+ 96·9	− 20·0	− 11·7	− 17·5	− 41·0	+ 4·1	+ 28·5	+ 43·4	+ 29·4	+ 47·9	+ 25·4	− 29·1	+ 24·1	+ 29·7	+ 21·6	+ 1·1	+ 19·3	+ 53·7
1917–18	− 28·6	− 15·2	+ 38·2	+ 29·4	+ 1·9	+ 43·2	− 3·9	− 27·1	+ 18·6	+ 17·5	+ 45·0	+ 10·4	+ 21·1	+ 8·6	+ 30·3	+ 16·7	+ 56·2	− 31·6
1918–19	+ 32·8	+ 1·1	+ 36·5	− 4·1	+ 29·0	− 99·0	− 24·4	+ 69·3	+ 85·7	+ 29·8	+ 24·6	+ 26·9	+ 4·7	+ 12·3	+ 14·2	− 28·8	+ 9·0	− 2·3
1919–20	+ 72·2	− 27·6	+ 2·0	− 3·8	+ 39·1	− 7·2	+ 34·1	+ 90·9	+ 27·4	− 55·0	− 40·0	+ 36·6	− 18·2	+ 2·8	+ 29·4	+ 24·0	+ 29·0	+ 60·7
Average.	+ 18·8	+ 5·5	− 8·2	− 17·2	− 35·2	− 17·0	− 28·8	− 14·2	+ 0·3	− 7·0	+ 8·4	+ 13·4	+ 24·5	+ 20·7	+ 33·4	+ 23·3	+ 22·4	+ 10·0
Average for 1st 12 years.	+ 10·6	+ 12·6	− 16·4	− 23·3	− 49·4	− 17·8	− 40·5	− 33·6	− 13·0	− 12·6	+ 6·6	+ 14·2	+ 30·0	+ 23·1	+ 36·6	+ 29·9	+ 20·3	+ 6·6
Average for the last 4 years.	+ 43·3	− 15·4	+ 16·3	+ 1·0	+ 7·3	− 14·7	+ 8·6	+ 44·1	+ 40·3	+ 10·1	+ 4·6	+ 11·2	+ 7·9	+ 13·4	+ 23·9	+ 3·3	+ 28·4	+ 20·1

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Diagram I

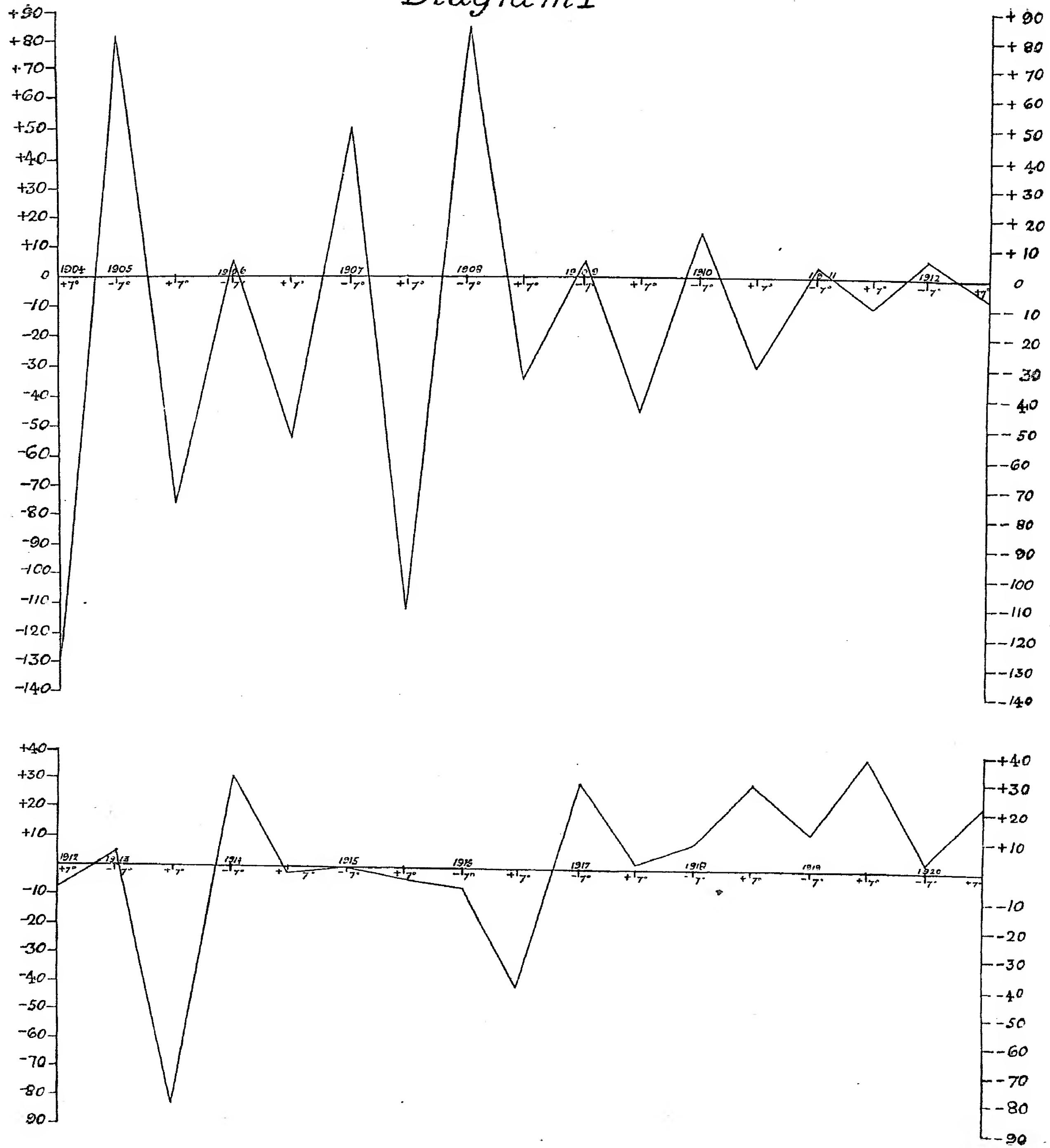
1904
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Diagram II

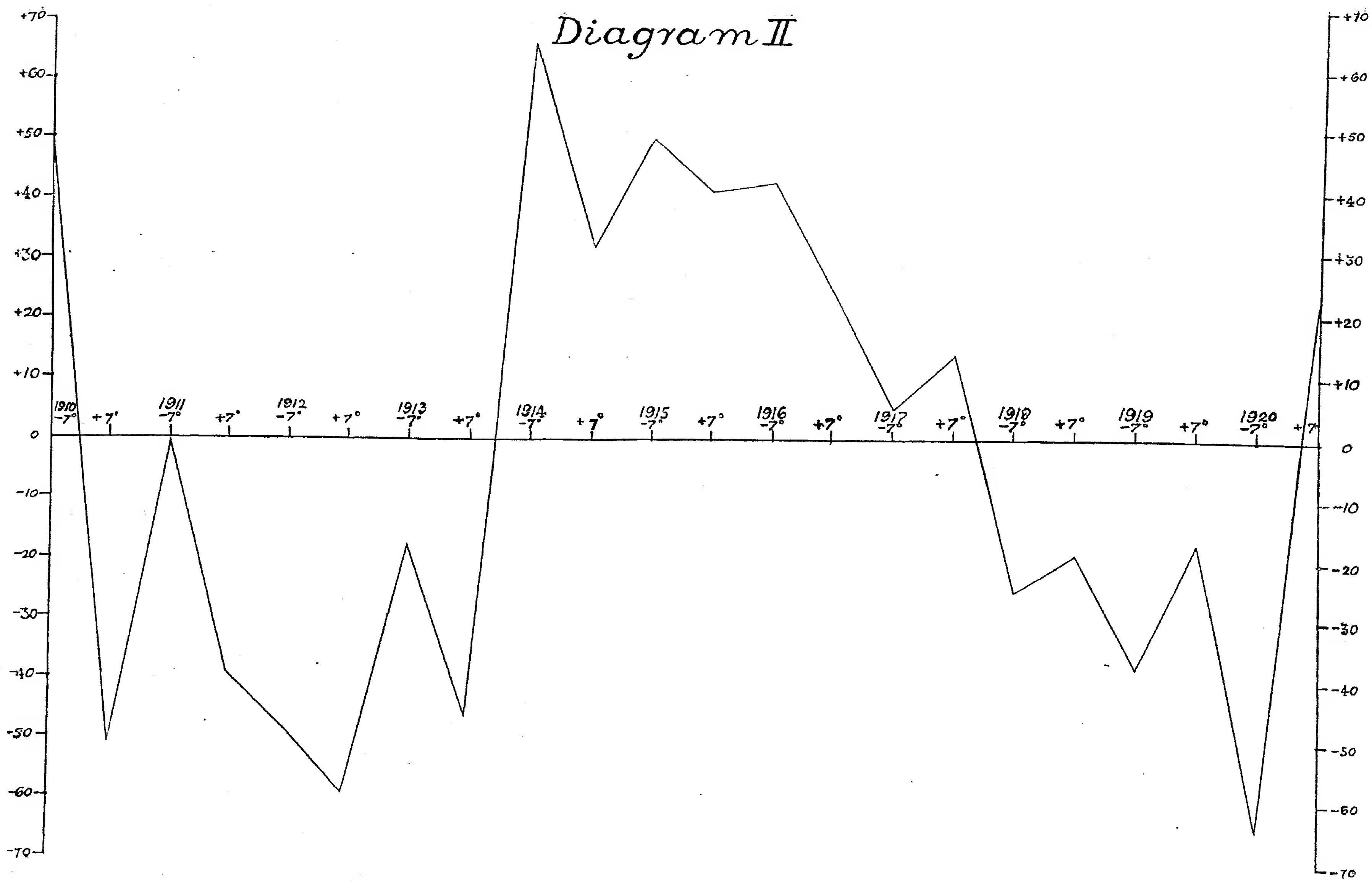
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Diagram III

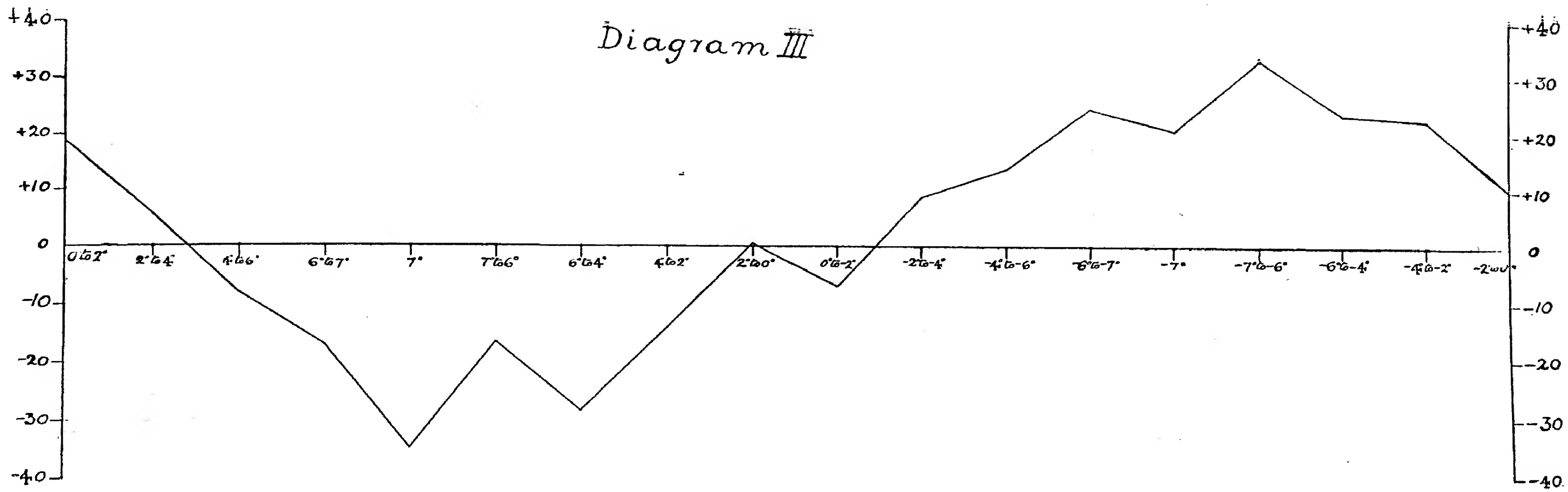
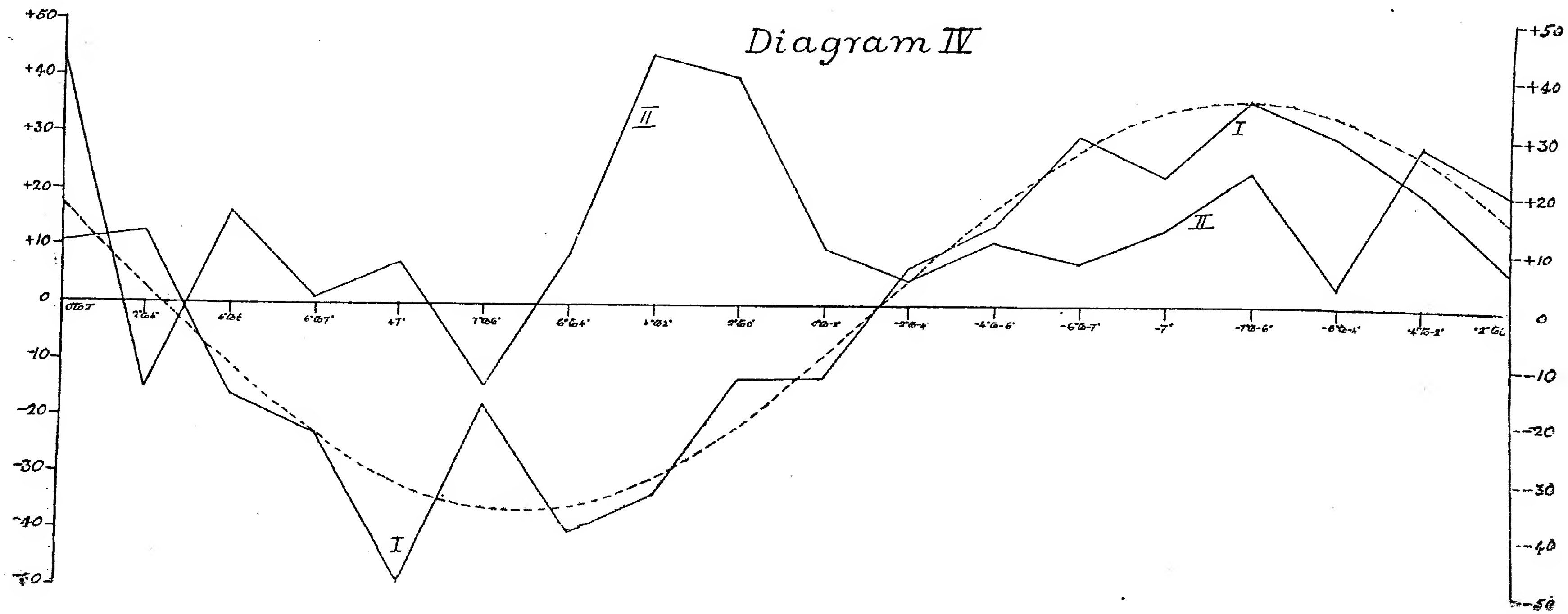


Diagram IV



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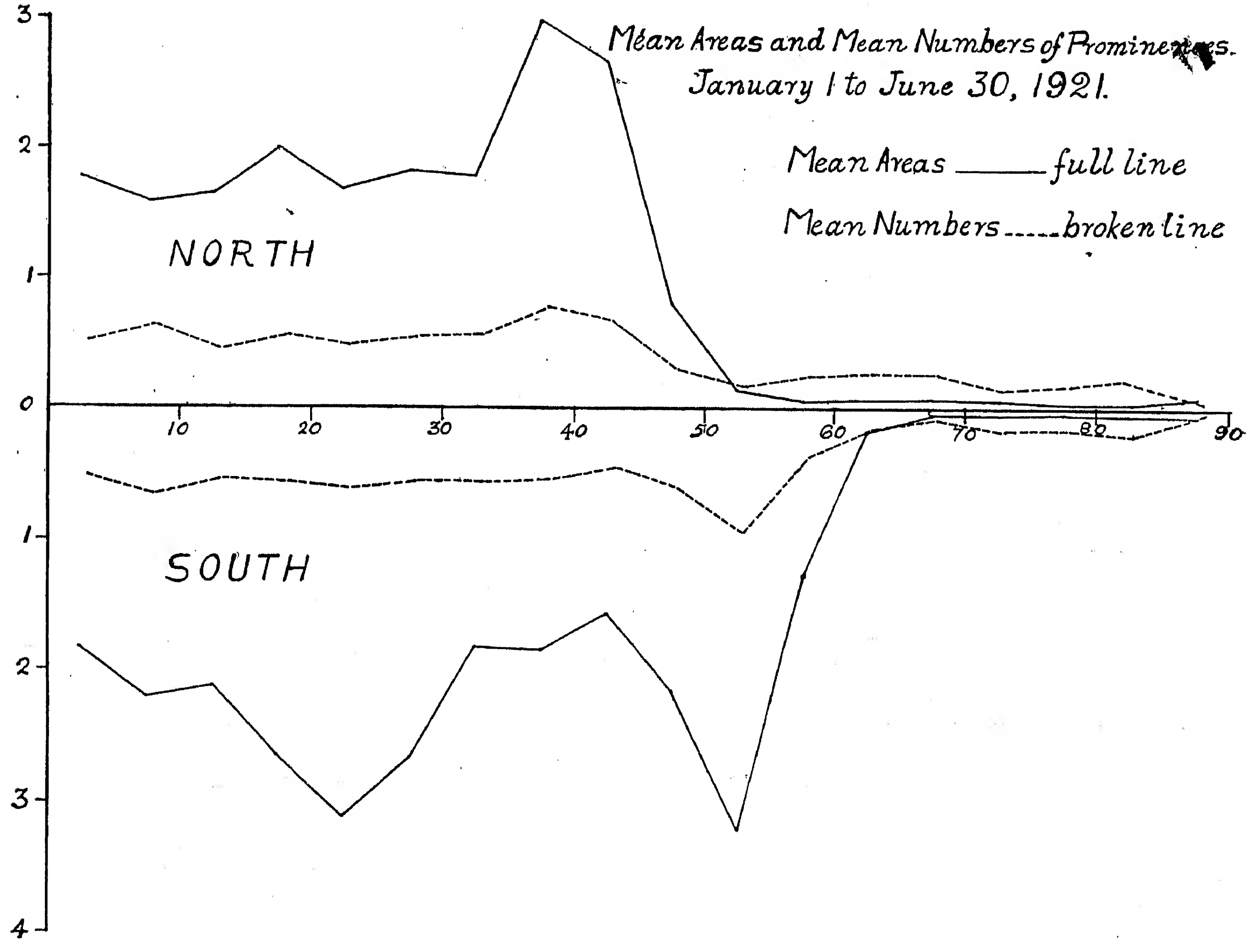
Kodaikanal Observatory.

BULLETIN No. LXVIII.

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE FIRST HALF OF THE YEAR 1921.

The distribution of prominences observed and photographed during the half-year ending 30th June 1921 is represented in the accompanying diagram, in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude. The ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line. The means are corrected for incomplete or imperfect records, the total of 171 days being reduced to 161 effective days.



Compared with the previous half-year the zones of greatest activity have advanced about 10° towards higher latitudes in both hemispheres. This is probably a temporary fluctuation as the regular advance towards the poles has not been observed previously until a few years before the epoch of maximum sunspots. There is still considerable activity in the equatorial region but this is likely to decrease during the next few years.

The mean daily areas and numbers corrected for imperfect observations are given below :—

	Mean daily areas (square minutes).	Mean daily numbers.
North	1·92	7·09
South	2·70	7·57
Total ...	4·62	14·66

Areas show a decrease of 9 per cent in the northern hemisphere and an increase of 24 per cent in the southern compared with the preceding half-year. In the case of numbers there is a general decrease amounting to 8 per cent. The activity is greater in the southern hemisphere in the case of both areas and numbers. The southern prominences are also on an average slightly brighter than the northern.

The monthly, quarterly and half-yearly areas and numbers, and the mean height and mean extent of the prominences are given in table I. The unit of area is 1 square minute of arc.

TABLE I.—ABSTRACT FOR THE FIRST HALF OF 1921.

Months.	Number of days (effective).	Areas.	Numbers.	Daily Means.		Mean height.	Mean extent.
				Areas.	Numbers.	″	°
January	22	104·2	321	4·74	14·6	31·3	3·77
February	26	139·8	390	5·37	15·0	32·5	3·82
March	31	142·8	465	4·61	15·0	32·9	3·79
April	29	142·0	406	4·90	14·0	34·3	4·58
May	30	138·9	460	4·63	15·3	32·0	3·67
June	23	76·3	319	3·32	13·9	30·8	3·14
First quarter	79	386·8	1176	4·90	14·9	32·3	3·79
Second quarter	82	357·2	1185	4·36	14·5	32·5	3·84
First half-year	161	744·0	2361	4·62	14·7	32·4	3·81

Distribution east and west of the Sun's axis.

Areas show a western excess in the first three months and an eastern excess in the last three, resulting in a slight western preponderance for the half-year. In the case of numbers, the activity was greater in the western hemisphere throughout the period.

1921 January to June.	East.	West.	Percentage east.
Total number observed	1154	1207	48·87
Total areas in square minutes	370·6	373·5	49·81

The average brightness of the western prominences was slightly greater than that of the eastern prominences.

Metallic prominences.

Thirty-five metallic prominences were recorded during the half-year of which as many as twenty-four were in southern latitudes. Details of these prominences are given in the table below :—

TABLE II.—LIST OF METALLIC PROMINENCES OBSERVED AT KODAIKANAL, JANUARY TO JUNE 1921.

Date.		Hour I.S.T.	Base.	Latitude. North.	Latitude. South.	Limb.	Height.	Lines.
1921.		H. M.	°	°	°		"	
January	6	9 15			15	W	80	5016, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316·8, D_1, D_2, 6677, 7065.
	15	14 52			11·5	E	40	b_1, b_2, b_3, b_4, D_1, D_2.
	17	9 55		11·5		W	50	b_1, b_2, b_3, D_1, D_2.
	23	9 26			23	W	50	4924·1, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	24	9 12		20		E	10	b_1, b_2, b_3.
	24	9 2	7		27·5	W	50	b_1, b_2, b_3, D_1, D_2.
	25	8 22			19	W	40	b_1, b_2, b_3, b_4, D_1, D_2.
	29	9 15	3		20·5	E	75	4924·1, 6677.
February	1	8 41			10·5	W	10	b_1, b_2. b_3, b_4, 5316 8, D_1, D_2.
	5	9 4	3		29·5	E	55	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
	6	9 0			25·5	E	70	5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	10	9 5			25·5	E	40	b_1, b_2, b_3, b_4, D_1, D_2.
	21	9 5	6		30	W	60	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	25	8 45	2		7	W	65	4922 4, 4924 1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5197·7, 5227·4, 5234·8, 5269·7, 5270·5, 5276·2, 5284·2, 5316·8, 5363·0, 5371·6, 5397·3, 5406·0, 5424·3, 5429·9, 5434·8, 5447·1, 5455·7, 5535·1, D_1, D_2, 6677, 7065.
	27	9 4			11	W	30	4924·1, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	28	9 16	13		23·5	W	30	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
March	3	9 10			24·5	E	85	b_1, b_2, b_3, b_4, D_1, D_2.
	5	9 35			22	E	135	b_1, b_2, b_3, b_4, D_1, D_2.
	6	9 32			10·5	E	40	b_1, b_2, b_3, b_4, D_1, D_2.
	13	9 15			22	E	55	b_1, b_2, b_3, b_4, D_1, D_2.
	20	9 38	3		28·5	W	30	b_1, b_2, b_3, b_4, D_1, D_2.
	21	8 55		18·5		W	20	5016, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 7065.
	24	9 4		15		W	145	4924·1, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677.
	25	9 20			19	W	40	5316·8.
April	4	9 22		18·5		E	50	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
	6	10 8	3		11·5	W	205	b_1, b_2, b_3, b_4, D_1, D_2, 6677, 7065 (metallic for 10" height only).
	10	8 52		8		E	60	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	29	9 2	2		12	W	20	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, 5363·0, D_1, D_2, 6677, 7065.
May	4	10 19		14		W	60	b_1, b_2, b_3, b_4, D_1, D_2.
	8	8 52	13	1·5		E	90	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5316·8, 5363·0, D_1, D_2, 6677, 7065.
	18	9 25		11		W	25	b_1, b_2, b_3, b_4, D_1, D_2.
	21	8 35	21		2·5	W	75	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5316·8, 5328·0, 5363·0, D_1, D_2, 6677, 7065.
	22	8 33		5		W	60	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 7065.
	26	10 42	16		10	E	50	4924·1, 5016, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
June	30	9 25	2	3		E	20	D_1, D_2, 6677, 7065.

The metallic prominences were distributed in latitude as follows :—

—	1° to 10°	11° to 20°	21° to 30°	Mean latitude.	Extreme latitudes.
				°	° °
North	4	7	...	11·5	1·5 and 20
South	3	9	12	18·4	2·5 and 30

Fifteen were on the east limb and 20 on the west.

Displacements of the hydrogen lines.

Particulars of the displacements observed in the chromosphere and prominences are given in the following table :—

TABLE III.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1921.		H.	M.	°	°		A.	A	A	
January	1	9	32		43	W	Slight			
	1	9	37		36	W	Do.			
	1	9	38		33	W		1		
	1	9	40		32	W	1			
	1	10	56	25		W	Slight			
	3	9	52	61·5		E	2			At top.
	4	8	38		6	E		Slight		
	4	8	43		15	W	Slight			
	5	9	42	85		E		1		
	5	9	38	33		E	Slight			
	5	9	7	4		E	Do.			
	5	10	2	29		W	1	Slight		
	7	9	13		25	W		4		At base.
	8	9	35		8	E		2		
	9	10	24		9	E	1			
	9	9	53	39		W	Slight			At top.
	9	9	48	47		W	1			
	15	15	8	77		E	1			
	15	15	3	47		E		Slight		
	15	14	58	29		E	2			
	15	14	56	21		E	2			
	16	9	5	30		W		0·5		At base.
	17	9	45	59·5		E	1			
	17	9	40		71	W	0·5			
	17	9	13	14		W	2	4		To red at base; to violet at top.
	22	10	35	10		W	1			At top.
	22	10	35	15·5		W	1·5			Do.
	23	9	22		17	W	1			At base.
	23	9	10	9		W	0·5			
	24	8	54	19		W	1·5			At top.
	25	8	27	17		E	Slight			
	25	8	20	4		W		0·5		At top.
	26	10	20		39	E	2			At base.
	27	8	24	42		W	1			
	29	9	15		20·5	E	6	3		At base. C was also displaced 2A to red and 1A to violet at top of prominence.
	29	9	0		45·5	E	Slight			At base.
	29	8	56		56·5	E	Do.			
	29	8	52		74	W		Slight		
	30	9	51		6	E		1		At base.
	30	9	51		8	E	1			Do.
	30	9	36		39	W		1		Do.
	31	8	30	69		E	0·5			
	31	8	34	70		E		Slight		
February	1	8	45	36		W	Slight			
	2	8	48	68		E	1			
	2	9	0		8	W		0·5		At base.
	3	9	25	14		E		2		At top.
	3	9	20	11		E		1		
	3	8	59		30	E	2			
	3	9	41		52	W		Slight		
	3	9	43		36	W	2			At top.
	4	8	50		54·5	W		0·5		
	4	8	40		5	W		Slight		
	4	8	40		8	W	Slight			
	5	9	4		24	E		1		
	5	10	10	83		W	Slight			
	6	10	27		15	E	1·5			At base.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1921.		H.	M.	°	°		A	A	A	
February	7	8	52		18	E		1		At top.
	9	8	35	54·5		W	0 5			
	10	8	59		40·5	E	1			At base.
	10	9	45		19	W	Slight			
	11	8	30	79·5		E		0·5		
	12	9	40	34		E	1			
	12	9	32	15		E		1		At top.
	12	9	20		30	E	Slight			At base.
	12	9	9		73	W	Do.			
	12	10	2		15	W		2		
	13	9	33	Equator		E		1		
	13	9	14		23	W		1·5		
	13	9	14		24	W	1			
	13	8	55	39		W	1			
	14	9	24		10	E		1·5		At top.
	16	9	7		6	E	1	1		To red at base; to violet at top.
	16	9	10		15	E	1			At top.
	16	8	52	71		W		0·5		
	18	8	40	32		E	1·5			At top.
	21	9	5		30	W	2	1		To red at top; to violet at base.
	21	8	52		11	W		0·5		At base.
	22	9	57		25	E		1		
	22	10	5		62	E		1		
	22	9	35		61	W	Slight			
	22	9	30		27	W	1			
	22	9	3	51·5		W	Slight			
	22	9	0	56·5		W		Slight		
	22	8	36	72·5		W	1			
	24	8	47		9	E		1		
	24	8	40		30	E		0·5		
	24	8	33		65	E		1		At top.
	24	9	23	5		W	Slight			
	25	8	45		7	W			1	
	25	8	40		2	W		2		
	26	8	32	22		E	Slight			
	26	8	45	11·5		E	2			At top.
	27	8	50		4	W	2			Do.
	28	9	28	10·5		E		1		Do.
	28	9	6		11	W	1			
	28	9	6		7	W	2			
March	1	9	18	16		E	4			
	1	9	45		7	W		1		At top.
	2	8	28	74·5		E	Slight			
	2	8	40		3	W		0·5		
	2	8	36	13		W	1			At top.
	3	9	35	71·5		E		Slight		
	3	9	29	7		E		Do.		
	3	9	12		20	E	2			
	4	8	36		30	W		Slight		
	4	8	32	63		W		Do.		
	5	9	44	27·5		E	1			
	5	9	41	26		E		1		
	5	9	26		21	E		1		
	5	9	23		25	E	2			
	5	9	31	30		E	1			At base.
	6	9	1	68		E		Slight		
	7	8	11	81·5		E	Slight			
	7	8	7	59·5		E		Slight		
	7	8	37	33·5		E	0·5			
	7	8	13	81·5		W	1			
	8	9	16		19	E	Slight	Slight		To red at base; to violet at top.
	9	8	39	54·5		E	1			
	9	8	51	10		W	0·5			
	10	9	12		8	E	1	2		To red at base; to violet at top.
	10	8	58		73·5	W	1			
	11	8	26		13	E	Slight			

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1921.		H.	M.	°	°		A	A	A	
March	12	8	11		8	E		1		
	12	9	52	28		W	Slight			
	12	9	57	77		W	Do.			
	13	8	50		52	W		Slight		
	13	8	51		56	W	Slight	1		At top.
	14	9	20		32·5	E	2			Do.
	14	9	4		58	W		0·5		At base.
	14	8	55		22·5	W	1			Do.
	16	8	51		25	W	1			
	16	8	44	24		W		Slight		
	17	9	24	55·5		E	Slight			
	17	9	34		30	W	1			
	17	9	40		28	W	1			
	18	8	34		34	E	Slight			
	18	8	38		70	E	Do.			
	19	8	44	34·5		E	1	0·5		To red at top; to violet at base.
	20	9	21	37·5		E		Slight		
	20	9	16	9		E			2	
	20	9	14		6	E		1		
	21	8	42	59·5		E	1			At top.
	21	9	18	15		E	2			At base.
	21	9	6		27	W		1		Do.
	21	8	55	20		W		Slight		
	21	8	46	31		W	1·5			
	22	9	16	25		E		Slight		At top.
	22	9	18	15		E			1	At base.
	22	9	20	9·5		E		1		At top.
	22	9	0		69	E		Slight		
	23	8	32	60		E	Slight			
	23	9	2		52	E	Slight			
	24	9	4	10		W	2	1		At base.
	25	9	8		33	E		0·5		Do.
	26	9	55		11	W	0·5			
	27	8	50	57·5		E		Slight		
	29	9	14		13·5	W	1			
	30	9	0	83·5		W	1			
April	2	9	20	12·5		E		2		At top.
	2	9	10		30	E	1			At base.
	2	9	7		37·5	E		1		
	3	8	38	62		E		Slight		
	3	9	12	18·5		E	2			At top.
	4	9	22	17		E	2·5	2		To red at top; to violet at base.
	5	8	42	58·5		E	0·5			
	6	9	29	60·5		E	1			
	6	9	37		23	W	1			At top.
	6	10	8		11·5	W	8	2		To red at top; to violet at base. Eruptive.)
	7	8	36	62·5		E	1			
	7	9	20		23	E	1·5			
	8	9	32	27		E	1			
	9	9	26	44		W		1		
	10	8	37	46·5		E		0·5		At base.
	10	8	42	53·5		W		Slight		
	11	8	40	64·5		E		0·5		
	11	8	51	7		E		Slight		
	13	8	56	56·5		E		0·5		
	15	8	32	50·5		E	1			
	15	8	37		6	W	1·5	1		
	16	9	42		53	W	Slight			
	16	9	8	12		W		1		At top.
	16	9	6	52·5		W	Slight			
	16	9	4	83·5		W	0·5			
	18	8	54	65·5		E	0·5			
	18	10	21	43·5		E		1		
	21	9	8		39	W	2	1		To red at base; to violet at top.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1921.		H.	M.	°	°		A	A	A	
April	22	8	44	67·5		E		0·5		At base.
	22	9	10		10	E	3	2		To red at base ; to violet at top.
	24	8	30	35·5		E	1			At base.
	24	9	1		47	E	0·5			
	24	9	4		84·5	E		0·5		
	24	8	35	61·5		W	0·5			
	26	8	57	77		E	0·5			At base.
	26	9	10	40		E	0·5			Do.
	27	9	7	31		E		1		
	27	8	52		25	E	5			
	27	8	48		52	E	Slight			At top.
	27	9	17	5		W		1		At base.
	28	8	30	78		E		Slight		
	28	8	28	63·5		E	0·5			At base.
	28	8	54		29	E	0·5			Do.
	28	8	42		2	W	Slight			
	28	8	36	15		W	1			At top.
	29	9	33	10		E	0·5			At base.
	29	9	2		12	W	2	3		To red at top ; to violet at base.
	29	8	47	36·5		W		1		At base.
	30	9	14		54·5	W	Slight			
	30	9	17		45	W	0·5			
	30	9	21	20·5		W	0·5			
May	1	8	35	26·5		E	1			At top.
	1	8	55		8	E		0·5		
	1	9	0		18	E	0·5			At base.
	1	8	44		11	W		Slight		Do.
	1	8	40	40		W	1			
	3	8	52	34·5		E	0·5			
	4	0	19	14		W	Slight			
	6	18	36	65		E	Do.			
	6	8	32	45		E		Slight		
	6	8	40	50		W	0·5			
	7	9	19	67·5		E		2		
	7	9	11	32		E		1		At base.
	7	9	5	24		E	1			Do.
	7	9	2	Equator		E	1			
	7	8	51		65	E		Slight		
	8	8	20	66		E		Do.		
	8	8	35	60·5		E	1·5	0·5		To red at base ; to violet at top.
	8	8	52	1·5		E	1	0·5		Do.
	8	8	30		16	W	0·5			
	9	9	30	2		E		1·5		
	9	9	30		8	E	1·5	1		To red at base ; to violet over middle of prominence.
	9	8	52	28		W	1·5	0·5		To red at top ; to violet at base.
	9	8	45	65		W		1		At base.
	10	9	40		39	E	1	2		To red at base ; to violet at top.
	10	8	58		14	W	0·5			
	10	8	49	24		W	0·5			At base.
	13	9	40	1		E	1			At top.
	15	10	0		21	E	1			At base.
	16	9	3		16	E	1·5			At top.
	18	10	29	22		E	1			
	19	8	50	66		E	0·5			
	19	10	22	43		E		0·5		At base.
	19	10	28	20		E	1	0·5		To red at base ; to violet at top.
	21	8	35	2		W	1	3·5		To red at top ; to violet at base.
	21	8	28	60		W	0·5			
	22	8	46		26	W		0·5		
	22	8	38		4	W	1			At top.
	23	9	0		42	E		1		Do.
	24	8	52	19		E	1			At base.
	24	9	12		27	E	0·5			Do.
	26	10	42		10	E	2	5		To red at base ; to violet at top.
	26	10	32	2		W	1			At base.
	27	9	22	75		W		0·5		

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1921.		H.	M.	°	°		A	A	A	
June	1	9	13	20·5		E		0·5		
	1	9	4		83·5	W		Slight		
	3	8	36	68		E		Do.		At base.
	3	9	5	5		E	1			
	3	8	52		46	W		0·5		At base.
	3	8	50		20	W	1			At top.
	3	8	45	7		W	1			At base.
	5	8	38		15	W	1			At top.
	5	8	27	61		W		0·5		At base.
	6	9	28	68		W		0·5		Do.
	7	9	37	44		W	1			
	14	11	18	83		E	0·5			
	16	10	52	10		E		3		At top.
	17	9	24		33	E	0·5			
	17	9	14	Equator		W	Slight			
	21	9	5	52		E	Do.			
	23	9	16	11		E	Do.			
	24	8	40	76		E		Slight		
	25	9	3	12·5		E	2			
	27	9	24		28	W		0·5		
	29	9	28	18		W	1			
	30	9	16	13		E	3	2		To red at base; to violet at top.

The total number of displacements was 300, of which three were on the equator, and the rest were distributed as follows :—

Latitude		North	South
1°—30°		76	89
31°—60°		45	33
61°—90°		42	12
	Total ...	163	134

East limb	168
West limb	132
Total ...	300

One hundred and seventy-four displacements were towards the red, 123 towards the violet and 3 both ways simultaneously. The greatest displacement observed was 8A to red over the upper portion of an eruptive prominence on April 6.

Reversals and displacements on the disc.

One hundred and fifty-one bright reversals of the $H\alpha$ line, 86 dark reversals of the D_3 line and 120 displacements of the $H\alpha$ line were recorded during the half-year. All these were in excess of the previous half-year, owing partly to more favourable observing conditions and partly to the appearance of very active spots on the Sun's disc. The large equatorial group of spots which crossed the central meridian on May 14-15 was the seat of very violent disturbances throughout the period it was visible. On one occasion (May 19) in addition to the hydrogen lines, the lines of sodium, magnesium and the enhanced lines of iron were observed to be brightly reversed over the umbra of the spot. Although reversals of the sodium and magnesium lines have been noticed on previous occasions, this is the first time that iron lines have been observed here to be so reversed. A photograph of the spot spectrum in the H and K region taken on May 14 at 8^h 15^m I.S.T., shows bright reversals of the stronger arc lines of iron, the aluminium lines and the silicon line at 3905·66, in an eruption between the principal spots of the group. The reversals and displacements were distributed as follows :—

	North	South	Equator	East	West
Bright reversals of Hα	72	67	12	69	82
Dark reversals of D_3	34	44	8	33	53
Displacements of Hα	51	54	15	49	71

Ninety-six displacements were towards the red, 25 towards the violet and 3 both ways simultaneously.

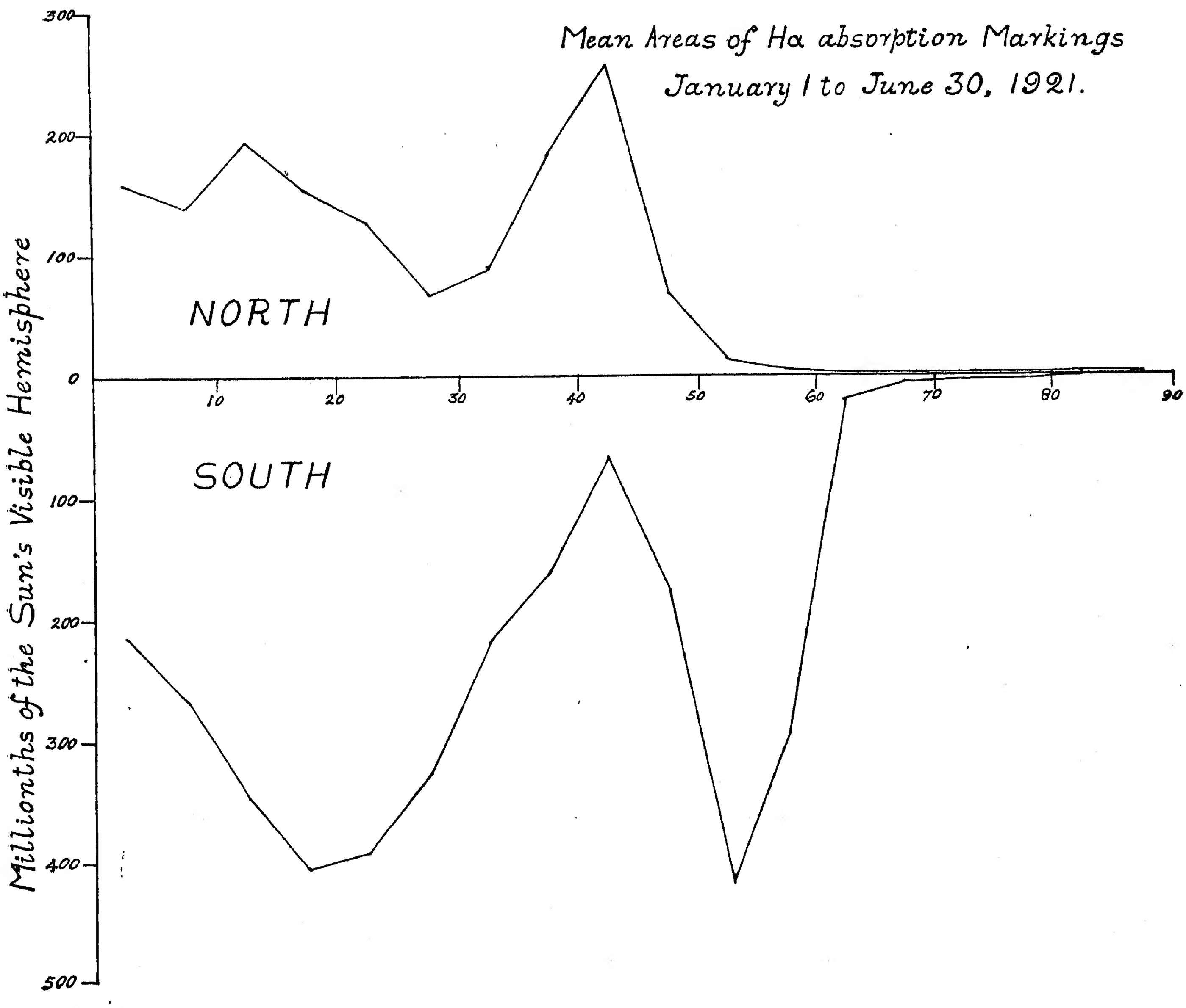
Prominences projected on the disc as absorption markings.

Photographs of the Sun's disc in Hα light were obtained on 157 days, counted as 150 effective days. The mean daily areas in millionths of the Sun's visible hemisphere, corrected for foreshortening, and the mean daily numbers are given below :—

	Areas	Numbers
North	1466	12·2
South	3332	22·1
Total ...	4798	34·3

Compared with the previous half-year both areas and numbers show a large decrease in the northern hemisphere and a large increase in the southern. In the case of areas the decrease in the north amounts to 44 per cent, and the increase in the south to 25 per cent. There results a large preponderance of activity in the south, as is also shown by the prominences at the limb.

The distribution of the mean daily areas in latitude is shown in the accompanying diagram :—



The distribution is practically the same as that of the prominence areas. Compared with the previous half-year the zones of maximum activity have moved towards the higher latitudes and as in the case of prominence areas, the curve is marked by a peak at about 40° in the northern hemisphere and between 50° and 55° in the southern hemisphere. In agreement also with the prominences at the limb areas show a western excess during the first quarter and an eastern excess during the second quarter. Numbers also show this distribution. For the whole period there was a slight eastern preponderance, the percentage east being 50·51 for areas and 50·76 for numbers.

THE OBSERVATORY, KODAIKANAL,
31*st August* 1921.

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Director, Kodaikanal and Madras Observatories.

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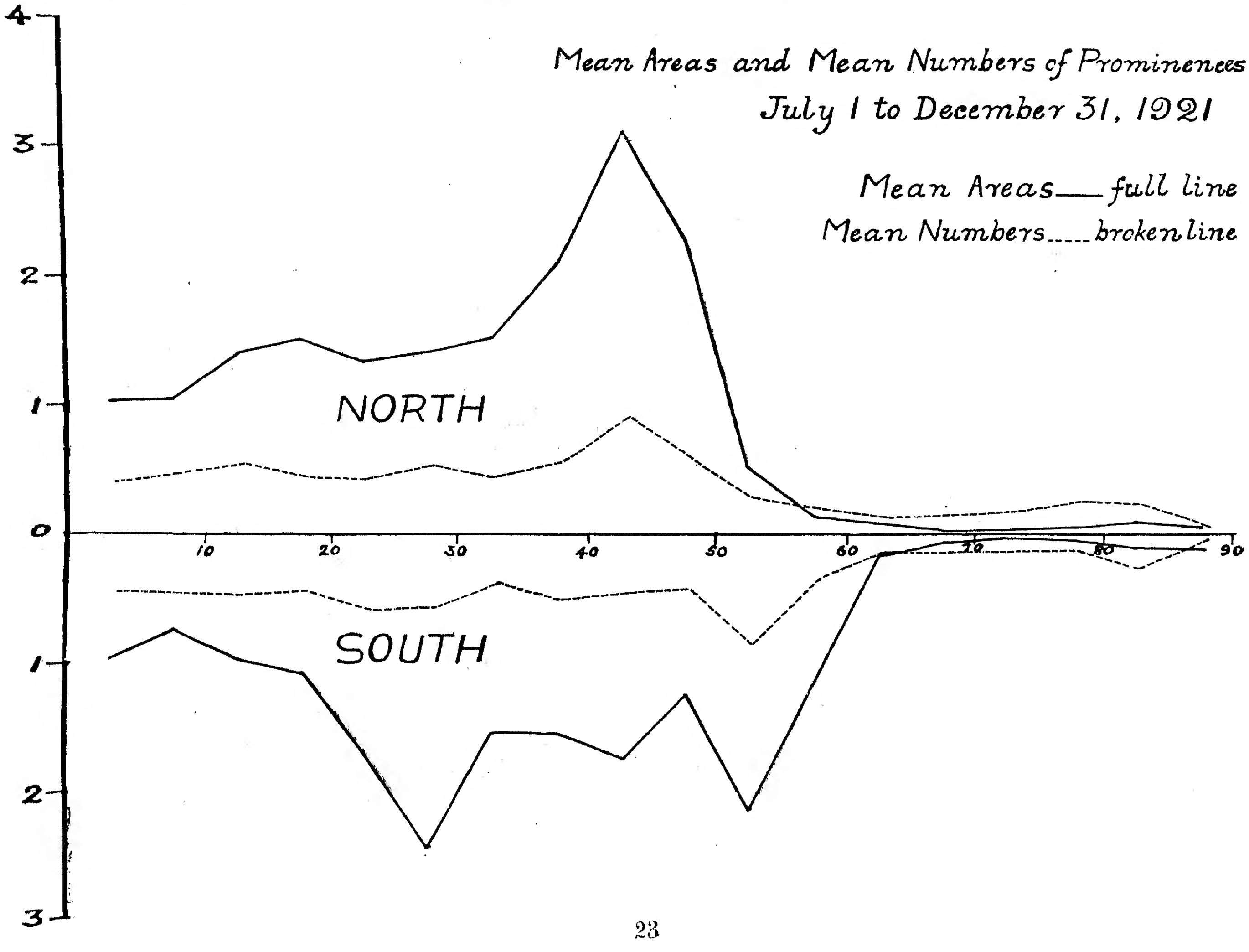
BULLETIN No. LXIX.

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE SECOND HALF OF THE YEAR 1921.

The distribution of prominences observed and photographed during the half-year ending 31st December, 1921, is represented in the accompanying diagram, in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude. The ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line. The means are corrected for incomplete or imperfect observations, the total of 156 days being reduced to 132 effective days.



The distribution curve is very much like that of the previous half-year even in detail. There is a slight diminution of activity in the equatorial region, and the zone of greatest activity has advanced 5° towards higher latitudes in the northern hemisphere.

The mean daily areas and numbers corrected for imperfect observations are given below :—

	Mean daily areas (square minutes).	Mean daily numbers.
North	1·76	6·56
South	1·79	6·96
Total ...	3·55	13·52

These figures represent a decrease of 23 per cent in areas and 8 per cent in numbers compared with the previous half-year. The decrease is more marked in the southern hemisphere in the case of areas and has resulted in equalising the activity in the two hemispheres. The southern prominences were slightly brighter than the northern.

The monthly, quarterly and half-yearly areas and numbers, and the mean height and mean extent of the prominences are given in table I. The unit of area is 1 square minute of arc.

TABLE I.—ABSTRACT FOR THE SECOND HALF OF 1921.

Months.	Number of days (effective).	Areas.	Numbers.	Daily Means. Areas.	Daily Means. Numbers.	Mean height.	Mean extent.
						″	°
July	16	52·0	194	3·25	12·1	30·1	3·10
August	24	67·6	339	2·82	14·1	27·7	2·75
September	22	89·1	261	4·05	11·9	33·6	3·87
October	21	83·2	285	3·96	13·6	33·8	3·65
November	24	90·3	403	3·75	16·8	30·7	3·03
December	25	86·5	313	3·46	12·5	31·7	3·17
Third quarter	62	208·7	794	3·37	12·8	30·2	3·21
Fourth quarter	70	260·0	1001	3·71	14·3	31·9	3·25
Second half-year	132	468·7	1795	3·55	13·6	31·2	3·23

Distribution east and west of the Sun's axis.

Both areas and numbers show a slight western preponderance as will be seen from the table below :—

1921 July to December.	East.	West.	Percentage east.
Total number observed	879	916	48·97
Total areas in square minutes	231·5	237·2	49·39

The average brightness of a prominence was the same on the east limb as on the west.

Metallic prominences.

Fourteen metallic prominences were observed of which seven were recorded during the month of December. Details of these prominences are given in the following table :—

TABLE II.—LIST OF METALLIC PROMINENCES OBSERVED AT KODAIKANAL, JULY TO DECEMBER 1921.

Date.		Hour I.S.T.	Base.	Latitude.		Limb.	Height.	Lines.
				North.	South.			
1921.		H. M.	°	°	°		″	
July	1	9 16		11		E	10	5016, 6677, 7065.
August	24	9 3		11		E	25	b_1, b_2, b_3, b_4, D_1, D_2.
	30	9 5	13	13		W	15	5016, b_1, b_2, b_3, b_4, 5197·7, 5234·8, 5270·6, 5316·8, 5363·0, D_1, D_2, 6677, 7065.
September	16	8 35			10	W	10	4924·1, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677.
	23	8 46		17		W	55	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
November	24	10 55		14		W	20	b_1, b_2, b_3, D_1, D_2.
	25	10 16		7		W	65	4924·1, 5016, b_1, b_2, b_3, b_4, 5270·5, 5276·2, 5316·8, D_1, D_2, 6677.
December	1	8 20			4	W	60	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677.
	2	8 35	4		1	W	20	4924·1, 5018·6, b_1, b , b_3, b_4, 5234·8, 5276·2, 5284·2, 5316·8, 5363·0, D_1, D_2, 6677, 7065.
	15	9 24	8		1	E	20	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	15	9 32			9	E	10	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	21	10 29	5	10·5		W	50	b_1, b_2, b_3, b_4, 5316·8.
	22	8 40	4	10		W	70	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5316·8, 5535·06, D_1, D_2, 5991·6, 6469·4, 6484·2, 6516·3, 6677, 7065.
	23	8 50		10		W	15	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, 5535·06, D_1, D_2.

The metallic prominences recorded above were distributed in latitude as follows :—

——	1° to 10°	11° to 20°	Mean latitude.	Extreme latitudes.
			°	° °
North	3	6	11·5	7 and 17
South	5		5·0	1 and 10

Ten were on the west limb and four on the east.

Displacements of the hydrogen lines.

Particulars of the displacements observed in the chromosphere and prominences are given in the following table :—

TABLE III.

Date.		Hour I.S.T.	Latitude.		Limb.	Displacement.			Remarks.
			North.	South.		Red.	Violet.	Both ways.	
1921.		H. M.	°	°		A	A	A	
July	1	9 16	11		E	2	2		To red at top, to violet at base.
	2	9 47	82·5		E		1		
	2	9 23	26		E	0·5			
	2	9 23	22		E		1		

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1921.		H.	M.	°	°		A	A	A	
July	3	8	23	40		W	Slight			
	3	8	22	54		W		Slight		
	6	10	26	Pole		...		1		
	6	9	50		9	E	1			
	6	10	20		4·5	W		2		
	7	9	28		10	W		0·5		At base.
	7	9	16		3	W	1			At top.
	10	8	52	45		W	0·5			At base.
	12	8	24	Equator		W	Slight			
	12	8	20		60·5	W		Slight		
	26	8	55	35		W		Slight		
August	4	10	34		8	E	1			
	5	8	32	40		E		Slight		
	6	8	57		5	W		1		At base.
	6	8	56		9	W	Slight			Do.
	7	8	32		77·5	W	1	Slight		To red at top, to violet at base.
	9	8	46	26		E	Slight			At top.
	9	8	44		7	E		Slight		
	9	8	51		82·5	W	Slight			
	12	9	3	6		W		Slight		
	13	8	59	35		E		Slight		
	13	8	46		41	E	1			
	13	9	23	13·5		W	1			
	14	8	37	42·5		W	1			At top.
	16	9	0	82·5		W	2			
	18	8	57	57		E		1		At base.
	19	8	49		1	W	1			At top.
	22	10	33	9		W	1			
	23	8	49	34		E	0·5			At base.
	23	8	52		12	E	Slight			
	24	9	15	83		E	1			
	24	8	49		66	E		Slight		
	24	9	35		21	W	1			
	24	9	35		24	W	0·5			
	24	9	17		70·5	W	0·5			
	25	8	48	77		W		1		
	26	9	26	22		E	Slight			
	29	9	24		6	E	1·5			
	29	9	16		21	W		1·5		At top.
	29	9	6	15		W	0·5			At base.
	29	8	58	67		W		0·5		Do.
	30	9	24		9·5	E	1			At top.
	30	9	5	13		W	2	1		To red at top, to violet at base.
	30	9	2	18		W		1·5		At base.
Sept.	3	9	25	82		E	1			At top.
	4	8	52	22		E	Slight			At base.
	4	8	40	18		W		0·5		Do.
	5	8	42	1		E		0·5		At top.
	5	8	46		23	E		Slight		
	10	9	44	54·5		E	0·5			
	13	8	35	34·5		W		Slight		
	16	8	30	82·5		W	Slight			
	17	9	36	14·5		E			1	At top.
	18	8	50	13		E	1			Do.
	19	8	36	74·5		E		0·5		
	19	8	49		31·5	W	1			At top.
	19	8	40	73·5		W	Slight			
	20	8	59	73·5		E	1			
	20	9	5	15		E	1·5			
	22	8	42	31·5		W		Slight		
	23	8	41	83		E		Slight		
	23	8	46	20		W			1	
	26	9	3		5	W	1			
	27	9	10		53·5	E		1		At base.
	27	8	47	21·5		W	0·5			Do.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1921.		H.	M.	°	°		A	A	A	
Sept.	30	9	20	8		W	2			
	30	9	16	44·5		W	1			At top.
October	1	10	6		2·5	W		1		
	2	8	35	74·5		E		Slight		
	6	8	20	52·5		E	0·5			
	14	8	40	57·5		W		Slight		
	14	8	32	67·5		W		0·5		
	15	9	31		14	E		1		At top.
	15	9	54		20	W	1			Do.
	16	8	50	43		W	1			Do.
	17	8	35		20	E		Slight		Do.
	17	8	54	64·5		W		1		Do.
	17	8	52	69		W	Slight			
	18	8	39		23	W	Slight			
	19	8	43		59·5	E	2·5			
	19	8	39		61·5	E	2			
Nov.	2	11	13	60·5		E		0·5		
	2	10	53	24		W		1		At top.
	3	9	40		83·5	E	0·5			
	7	10	21	23·5		W	1			At base.
	10	8	43		35	E		Slight		
	11	8	26	6		E		1		Over upper part.
	11	8	23		48·5	E	Slight			
	11	8	20		52	E		Slight		
	12	9	34	7		E	1			
	12	9	26	6		E	1			At base.
	12	9	15		72	E	0·5			
	13	8	36	13		E	1·5			At base.
	13	8	24		16	E		1		At top.
	14	8	54		52	E	0·5			At base.
	14	9	29	9		W		Slight		At top.
	14	9	39	72·5		W	2			
	15	8	25	75·5		E		Slight		
	15	8	28	59		W			Slight	
	16	8	45		40·5	E		1		
	17	8	33	64		E		1·5		At top.
	17	8	40		35	E	0·5			Do
	17	8	28		2·5	W			Slight	
	19	8	42		6	E	Slight			
	19	8	38		50	E	Slight			
	21	10	16	47		E		Slight		
	22	8	55		5	W		Slight		
	23	10	29	52		E		Slight		At top.
	23	8	55		65	E	1			
	23	10	46	46		W	1			At top.
	24	9	57	69		W		1		At base.
	25	10	14	7		W	3			At top ; only 1 A at 9h 54m.
	27	9	16	4		E	1			No prominence.
	28	9	6	13		E	0·5			
	29	8	35	47		E		Slight		
	30	8	56	3·5		W	1	0·5		To red at top, to violet at base.
	30	8	48	6		W	1			
	30	8	46	35		W	0·5			At top.
	30	8	42	77		W	0·5			
Dec.	1	8	36	78		E		Slight		
	1	8	30		4	W	3	2		To red at top, to violet at base. D_3 was displaced 2 A to violet at base. D_1 and D_2 were displaced 1 A to violet at base.
	1	8	55		12	W		1		At top.
	2	8	40		34	W		Slight		
	2	8	35	0·5		W	Slight	Slight		To red at north end, to violet at south end.
	2	8	22	83		W		Slight		
	3	8	41	49		E		Slight		
	3	8	34		59	E	Slight			
	3	8	55		83	W		Slight		
	3	8	50		39	W		Slight		At top.

Date.		Time I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1921.		H.	M.	°	°		A	A	A	
December	6	8	30		16	W		Slight		
	6	8	25	83		W				
	7	9	6		18	E	1·5			
	7	9	2		32	E		2		
	7	9	0		41	E	1			
	10	10	13	21·5		E		1		
	10	9	45		57	E		Slight		
	10	10	26		41	W		1		At base.
	10	10	37	43		W	1			Do.
	11	8	28		28·5	W		Slight		
	11	8	25	50		W			Slight	
	12	8	42		13	E		1		At top.
	12	8	38		46	W	1			Do.
	12	8	56	18		W	0·5			
	12	8	50	70		W		0·5		No prominence.
	13	8	48		63	E			Slight	Symmetrically widened.
	13	8	35		32	W		Slight		At base.
	13	8	30	73		W	Slight			
	14	8	51		8	E	1	0·5		To red at base, to violet at top.
	14	9	35		51	E	2			
	15	8	46	75		E		Slight		No prominence.
	15	9	7	35		E	Slight			At base.
	15	8	44	56		W		2		
	16	8	58	28		E		Slight		
	19	8	50	62		W		Slight		
	20	8	55		54	E	Slight			At base.
	21	10	34	5		W	1	2		
	21	10	0	10·5		W	3	2		At top. At 10^h 11^m the displacement was 1 A to red and 2 A to violet.
	22	8	34	74		E		0·5		
	22	8	40	9		W	6	4		D_3 was displaced 6 A to red and C was displaced 6 A to violet at 8^h 45^m.
	23	8	53		4	W			0·5	
	23	8	50	10		W		1		
	23	8	41	57·5		W		Slight		
	25	9	54	69		E		Slight		No prominence.
	25	10	0		56	W		0·5		
	26	8	41	19		W		Slight		
	26	8	38	36		W		0·5		

The total number of displacements was 180, which is only 60 per cent of the number observed in the first half-year. One of them was on the equator, and the rest were distributed as follows :—

Latitude		North	South
1°—30°		48	36
31°—60°		29	23
61°—90°		31	12
	Total ...	108	71

East limb	... ...	86
West limb	... ...	93
Pole	... ...	1
	Total ...	180

Eighty-six displacements were towards the red, 87 towards the violet and 7 both ways simultaneously.

Reversals and displacements on the disc.

One hundred and twelve bright reversals of the Hα line, 43 dark reversals of the D_3 line and 57 displacements of the Hα line were recorded during the half-year. Their distribution is shown below :—

	North	South	East	West
Bright reversals of Hα	68	44	59	53
Dark reversals of D_3	34	9	26	17
Displacements of Hα	37	20	25	32

Of the displacements, forty-one were towards the red, thirteen towards the violet and three both ways simultaneously.

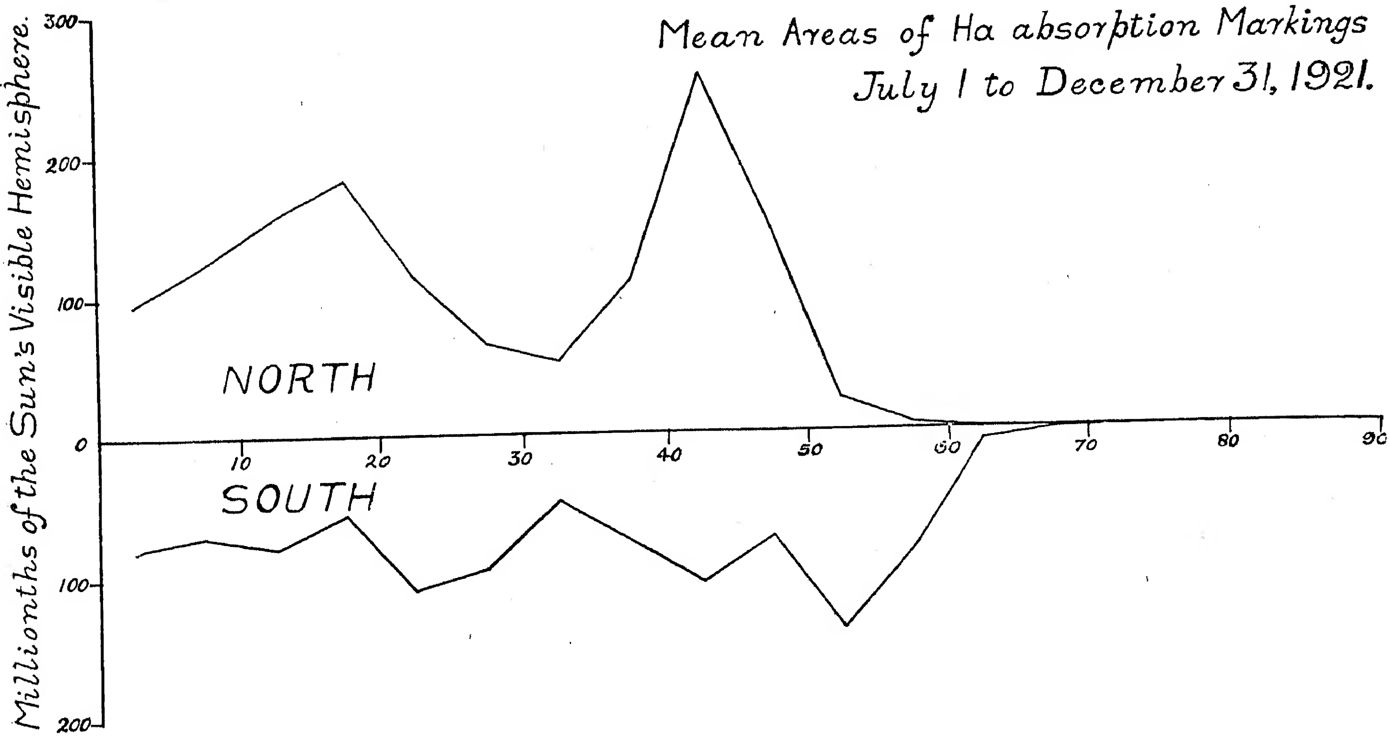
Prominences projected on the disc as absorption markings.

Photographs of the Sun's disc in Hα light were obtained on 130 days counted as 107 effective days. The mean daily areas in millionths of the Sun's visible hemisphere, corrected for foreshortening, and the mean daily numbers are given below :—

	Areas	Numbers
North	1328	12·6
South	1042	9·6
Total ...	2370	22·2

There is a large reduction both of areas and numbers compared with the previous half-year. In the case of areas the decrease amounts to more than 60 per cent in the southern hemisphere and only 10 per cent in the northern. There results a preponderance of activity in the northern hemisphere.

The distribution of the mean daily areas in latitude is shown in the following diagram :—



The activity is confined to the region between the equator and latitude 60° north and south. The reduction of area in the southern hemisphere is much more marked than in the case of prominences at the limb. The activity in this hemisphere is now more uniform in all the zones with the maximum at 50°—55°. In the northern hemisphere, the maximum activity occurs at 40°—45° as in the case of prominences at the limb. The Hα absorption markings have now reverted to an eastern excess, the percentage east being 54·40 in the case of areas and 52·45 in the case of numbers.

THE OBSERVATORY, KODAIKANAL,
31st January 1922.

J. EVERSHED,
Director, Kodaikanal and Madras Observatories.

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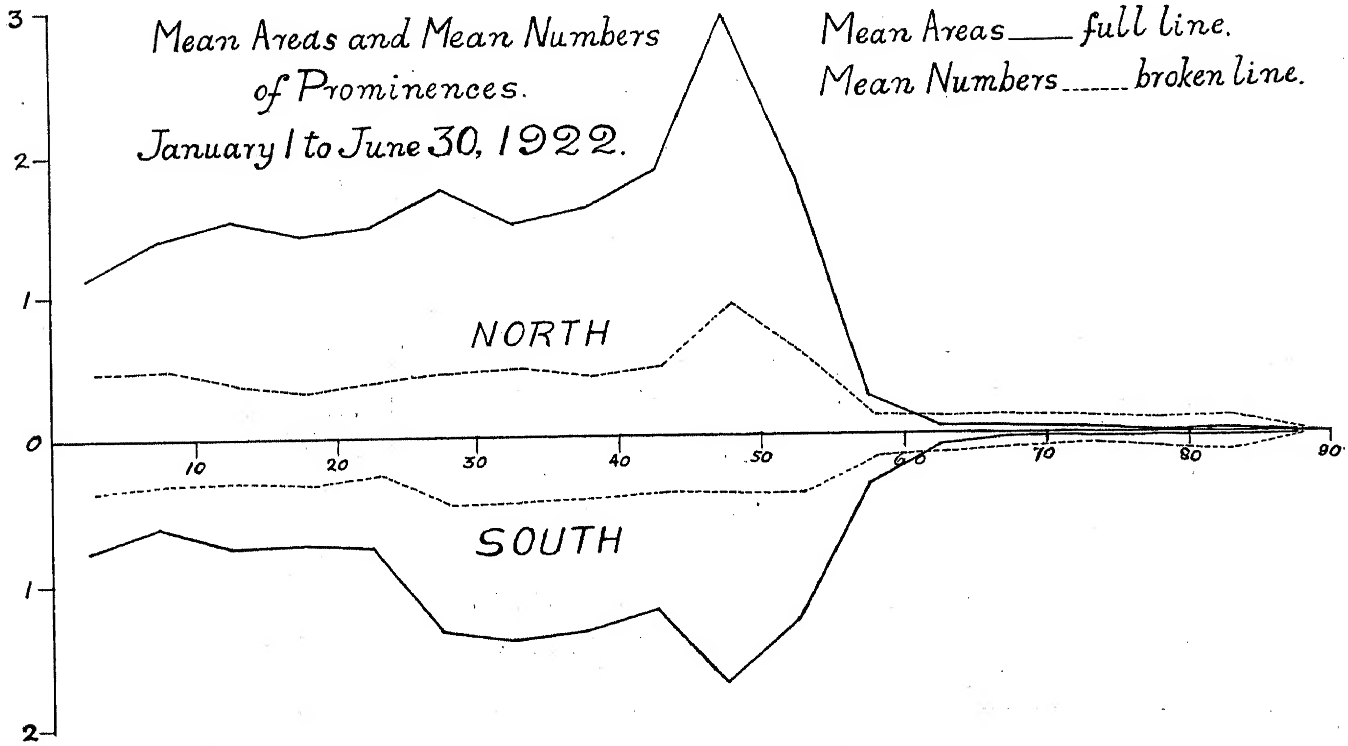
Kodaikanal Observatory.

BULLETIN No. LXX.

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE FIRST HALF OF THE YEAR 1922.

The distribution of prominences observed and photographed during the half-year ending 30th June, 1922, is represented in the following diagram, in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude. The ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line. The means are corrected for incomplete or imperfect observations, the total of 161 days being reduced to 153 effective days.



The curve shows maxima in the belt 45°—50° in both hemispheres and is very similar to that for the previous half-year.

The mean daily areas and numbers corrected for imperfect observations are given below :—

	Mean daily areas (square minutes).	Mean daily numbers.
North	1·90	6·15
South	1·27	4·90
Total ...	3·17	11·05

Compared with the previous half-year, both areas and numbers have decreased by about 30 per cent in the southern hemisphere; in the northern hemisphere areas show a slight increase and numbers a slight decrease. On the whole there is a decrease of 11 per cent in areas and of 18 per cent in numbers. Prominence activity is now more pronounced in the northern hemisphere, in which the mean daily areas are 50 per cent and the mean daily numbers about 25 per cent more than in the southern. The northern prominences were also slightly brighter than the southern.

The monthly, quarterly and half-yearly areas and numbers, and the mean height and mean extent of the prominences are given in table I. The unit of area is 1 square minute of arc.

TABLE I.—ABSTRACT FOR THE FIRST HALF OF 1922.

Months.	Number of days (effective).	Areas.	Numbers.	Daily Means.		Mean height.	Mean extent.
				Areas.	Numbers.		
						″	°
January	28	83·8	334	2·99	11·9	27·8	2·98
February	22	70·4	256	3·21	11·6	33·1	3·55
March	31	107·0	367	3·45	11·8	34·0	3·95
April	27	99·3	297	3·68	10·0	36·7	4·87
May	23	70·6	236	3·07	10·3	33·8	4·08
June	22	54·2	201	2·46	9·1	36·8	4·09
First quarter	81	261·2	957	3·22	11·8	31·6	3·50
Second quarter	72	224·1	734	3·11	10·2	35·8	4·41
First half-year	153	485·3	1691	3·17	11·1	33·4	3·90

Distribution east and west of the Sun's axis.

Areas show an excess in the western hemisphere, but in the case of numbers there is a slight eastern preponderance as shown below :—

1922 January to June.	East.	West.	Percentage east.
Total number observed	857	834	50·7
Total areas in square minutes	234·0	251·3	48·2

The average brightness of a prominence was the same on the east limb as on the west.

Metallic prominences.

The activity of prominences showing metallic lines which was noticed in December 1921 was well maintained during the first three months of the period under review. During the half-year 34 metallic prominences were seen. Details of these are given in the following table :—

TABLE II.—LIST OF METALLIC PROMINENCES OBSERVED AT KODAIKANAL, JANUARY TO JUNE 1922.

Date.		Hour. I.S.T.	Base	Latitude. North.	Latitude. South.	Limb.	Height.	Lines.
1922		H. M.	°	°	°		″	
January	4	9 12		9		E	55	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
	5	8 40	5	10·5		E	40	4924·1, b_1, b_2, b_3, b_4, 5234·8, 5316·8, D_1, D_2, 7065.
	6	8 54	3	7·5		E	15	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8 D_1, D_2, 7065
	8	8 55		21		E	30	b_1, b_2, b_3, b_4, 5316 8, D_1, D_2.
	17	9 3	1	5·5		W	10	4924·1, b, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
	31	9 5	3	9·5		E	20	b_1, b_2, b_3, b_4, 5316·8.
February	1	8 58		18·5		E	165	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	15	9 33		11·5		W	70	4921·9, 4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5197·7, 5234·8, 5275·4, 5276·2, 5284·3, 5316·8, 5363·0, D_1, D_2, 6677, 7065.
	19	9 50			1	W	30	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5284 3, 5316·8, D_1, D_2, 6677, 7065.
	20	8		79·5		E	15	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, D_1, D_2.
	26	8 45		6·5		E	50	4924 1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677
	27	9 2	1	14·5		E	10	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	28	8 53	8	17		E	80	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
	28	8 55	4		10	E	20	b_1, b_2, b_3, b_4, 5316·8 D_1, D_2, 6677, 7065.
March	1	9 19		23·5		E	55	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	6	10 8	5	14·5		E	30	4922·3, 4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5222·1, 5234·8, 5270·5, 5273·4, 5276·2, 5316·8, D_1, D_2, 6677, 7065.
	8	9 14		12		W	55	4922·3, 4924·1, 5016, 5018·6, 5048·2, b_1, b_2, b_3, b_4, 5197·7, 5234·8, 5276·2, 5284·3, 5316·8, 5363·0, 5425·4, 5535·1, D_1, D_2, 6677, 7065.
	9	9 4	6	12		W	40	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	10	8 45	4	12		W	35	4922·3, 4924·1, b_1, b_2, b_3, b_4, 5234·8, 5316·8, D_1, D_2, 6677, 7065.
	14	8 30	2	23·5		W	45	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
	18	8 22		3		W	25	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5316·8, 5535·1, D_1, D_2, 6677.
	19	9 5	5		5·5	W	25	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
	19	8 52	2	11		W	10	5016, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677.
	20	8 42	1		32	W	20	4924·1, 5016, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	20	8 56		8		W	15	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5316·8, 5363·0, D_1, D_2, 6677, 7065.
	23	9 11		9·5		E	80	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
	24	9 30	11	16·5		E	25	4924·1, 5016, b_1, b_2, b_3, b_4, 5234·8, 5316·8, 5363·0, D_1, D_2.
	27	9 20	3	9·5		E	15 70	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
	28	9 45		26		E		4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5316·8, 5363·0, D_1, D_2.
	31	9 5		11		E	15	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5204·7, 5208·6, 5227·2, 5234·8, 5269·7, 5276·2, 5283·8, 5316·8, 5363·0, D_1, D_2, 6677, 7065.
April	3	9 3		24		E	45	b_1, b_2, b_3, b_4, D_1, D_2.
	7	9 5	3	8·5		E	40	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
May	20	8 36	5	8·5		E	25	b_1, b_2, b_3, b_4, 5316·8 D_1, D_2.
June	15	8 40	3	5		E	35	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.

The distribution in latitude of the metallic prominences s as follows —

—	1 t 10	11 t 20	21 to 30	31 t 40°	71 t 80	M l t t d	Extr m l tatud
N rth	12	12	5		1	15 0	3 d 79 5
S th	3			1		12 1	1 nd 32

Twenty two were on the east limb and 12 on the west

Displacements of the hydrogen lines

Particulars of the displacements observed in the chromosphere and prominences are given in the following table —

TABLE III

D t		H ur I S T		L t t d		L mb	D pl m t			Remarks
				N rth	S uth		R d	V l t	B th w ys	
1922		H	M				A	A	A	
J uary	2	10	50	70 5		W		Sl ght		
	4	9	12	9		E		1		At t p
	4	9	12	4		E		1		D
	4	9	4		46	E	1			At bas
	5	8	44	64		E		Sl ght		D
	5	9	7	20		E		1		At t p
	5	8	40	10 5		E	1 5			At bas
	5	8	46	66		W			Sl ght	
	7	10	7		49	W	0 5			At t p
	8	8	55	21		E		1 5		Do
	8	9	4	2		W	1 5			
	12	8	52		1 5	E	1			At b
	12	9	16		30	E	1			D
	12	9	0	30		W	1			
	12	8	56	50		W		Slight		At b
	13	9	4	59 5		E	1 5			
	13	9	13		14	W	Slight			
	14	10	30		2	E	0 5			
	15	8	46	43		W		Sl ght		At ba o
	16	8	36		67 5	E	3			
	17	8	38	50		E		0 5		At bas
	17	9	0	8 5		W	3	2		T ed at top to v olet at base
	18	9	12	1		L	1			
	18	8	54	41		W	0 5			At t p
	19	8	48	83		E		0 5		
	19	9	8	4 5		E	1			At l a
	19	8	52	71 5		W		Sl ght		
	20	8	56	20		E		Slight		
	20	8	56		19 5	E	Sl ght			
	21	9	4	56 5		E		0 5		
	21	9	10	68		W		0 5		At l a o
	22	9	36	49 5		L		S ght		At t p
	23	9	29		46 5	E	Slight			
	23	8	36	38		W	0 5			At ba
	23	8	36	35		W	1			At top
	23	8	31	54 5		W	0 b			
	24	8	47	59 5		W		Sl ght		
	25	9	32	84 5		E		2		At top
	25	8	44		52 5	E			0 5	
	25	9	14		30	W	Slight			At t p
	26	8	55		8	W	1			D
	26	8	50	18		W		0 5		
	27	8	35	51 5		E	Slight			
	28	9	38	33		E		Slight		At t p
	29	8	37	72		E	1			D
	29	9	2	4		E		1		At b s
	29	8	42	51		W	2			At top
	31	9	15	21		E	1	1		T ed a p to v olet t b e
		9	15	7		E		1		At base A to ed whol he ght at 11h 45
	31	9	18		P l		3			O wh l promin ce

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1922.		H.	M.	°	°		A	A	A	
February	1	9	46	20		E	1·5			At base.
	1	8	58	15		E	4			Do.
	1	9	8	14		E	2			
	1	9	8	6		E		1		
	1	8	50		31	E	2			At base.
	1	8	45		82	E	1			
	1	10	3	70		W	2			At top.
	4	11	15	15		E		1		Do.
	4	11	3		79·5	W	1			
	4	11	29	39·5		W	0·5			
	6	8	40	75		E	1			At top.
	6	8	44	41·5		E		1		
	7	9	15		56·5	E	1·5			
	8	9	41	47·5		E		1		Over whole height.
	8	9	28	14		E	0·5			
	8	9	9		50·5	E	Slight			At base.
	8	9	52		18	W	2			At top.
	11	9	55	71		E	1			
	11	9	23		9	E	1			
	12	8	48	33·5		E	Slight			
	12	8	36	41·5		W		3		
	15	9	7	54·5		E	1·5			
	15	9	33	9·5		W	1			
	15	9	33	13		W	2·5	2		Over whole prominence.
	18	9	16		39	E	1			At top.
	19	9	19	69		E	1			At base.
	19	9	13	35		E	1			Do.
	19	9	50		2	W	2	2		
	19	9	50	Equator		W	1	1		
	20	8	31	71·5		E		Slight		At base.
	21	8	39		61	E		Slight		
	21	8	40		70	E	0·5			
	22	8	58		2·5	E	2			
	23	8	54	6·5		E		0·5		At base.
	24	9	0		3·5	W	1·5			
	26	8	45	8·5		E		0·5		
	26	8	34	51·5		W		0·5		
	28	8	53	12		E	1·5			
	28	8	44		22	W	1			At top.
March	1	9	53	66		E	0·5			
	2	9	26	6		E		1		
	2	9	13	48		W	1			At top.
	3	8	42	46·5		E		Slight		
	3	8	36		8	W	Slight			At top.
	4	9	15	62		E		1		
	4	8	58		1	E	1			At base.
	6	10	8	14·5		E	1·5	2		
	7	8	35		38·5	E	0·5			
	8	9	14	9		W	6	3		
	9	9	22		2	W		1·5		At base.
	10	8	45	12		W		0·5		
	11	9	21	57		E		1		At top.
	11	9	27	22		W	Slight			Do.
	12	8	55	51·5		E		0·5		At base.
	12	9	10	15·5		W		1		Do.
	12	9	10	19		W	1			At top.
	13	10	12	1		E	1			
	13	9	15	13		W		1		At base.
	14	8	32	80		W		Slight		
	15	9	14	9		W	1			At top.
	15	9	26	70		W	2			
	16	8	57	78·5		E	1			At top.
	16	9	21	4		E		1		Do.
	16	9	1	47		W	1			Do.
	17	8	30	53·5		W	3			At base.
	18	8	32		60	E	1			
	18	8	22	Equator		W		Slight		
	19	9	27		74·5	W		0·5		

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1922.		H.	M.	°	°		A	A	A	
March	19	9	5		3	W	2			At top.
	20	8	39		6	W	1			Do.
	20	8	53	7		W		2		Do.
	20	8	53	9		W	1			At base.
	22	8	46	7		E		1		
	23	9	11	9		E	3	1		
	24	8	42	64		E		1·5		At base.
	26	9	2	78·5		W	0·5			Do.
	27	9	5		30	E		1		Do.
	27	9	10		82	E	2			Do.
	28	9	50		5	E		0·5		Do.
	30	9	6	15		W	1			At top.
	31	9	15	48		E		0·5		At base.
	31	9	5	11		E		2		Do.
April	2	9	20		4	W	0·5			
	2	9	17	12		W		0·5		At base.
	4	8	55	56·5		E	Slight			
	4	8	52	27		E	1			
	4	9	16		54·5	E	0·5			At base.
	4	9	6		3	W		Slight		Do.
	5	8	57		78·5	W	Slight			
	6	8	34		62	E	Slight			
	6	8	58		2	E	Slight			
	6	8	49	25		W		0·5		At base.
	7	9	5	8·5		E		2		At top.
	9	8	42	47·5		E		0·5		
	12	9	52		15	E	Slight			At base.
	12	9	48		57·5	E	1			
	16	8	32	72		E		0·5		At base.
	16	8	45		25	E		0·5		At top.
	17	9	7	52		E	0·5			At base.
	20	8	26	36		E	3			Do.
	20	8	40		8	W	1			Do.
	21	8	50		20	E	3	4		To red at base, to violet at top.
	21	8	58		46·5	E	0·5			At base.
	21	8	58		48	E		1		At top.
	22	8	53		71	W	Slight			To red at base, to violet at top.
	23	8	53	61·5		E		0·5		At base.
	23	9	4	47·5		W		0·5		Do.
	25	9	12	31		E	0·5			At top.
	25	9	10	11		E		Slight		At base.
	27	9	16	66·5		E		Slight		
	27	9	10	48		E		Slight		At base.
May	1	9	9	58		E	Slight			Do.
	1	8	57	1		E		1		At top.
	2	8	52	28		W		0·5		At base.
	4	9	2	19		E	1·5	1		To red at top, to violet at base.
	9	8	32	66		E	Slight			At base.
	9	8	49		36	W		2		Do.
	9	8	42	11		W	Slight			
	10	8	55	63		E	2	1		To red at base, to violet at top.
	11	9	12	55		E		Slight		At base.
	11	9	26		31	W	Slight			
	11	9	16	37		W	1			At top.
	18	8	40		7	E		Slight		
	19	9	5	25		E	Slight			
	19	9	1	5		W	Slight			
	19	8	54	83·5		W	0·5			At top.
	20	8	28	15		W	Slight			
	20	8	25	52·5		W	Slight			
	21	9	2	74		E	1			At top.
	21	9	21	68		E		0·5		At base.
	21	9	22	2		E	0·5			
	25	9	2	56		W	1			At top.
	27	9	28	65		E		Slight		
	28	8	28	82		E		Slight		At base.
	28	8	33		30	W	0·5			Do.
	29	8	36	47		E		0·5		Do.

Date.		Hour I.S.T.	Latitude.		Limb.	Displacement.			Remarks.
			North.	South.		Red.	Violet.	Both ways.	
1922.		H. M.	°	°		A	A	A	
May	30	8 49	39		E	Slight			
	31	9 30	46		W	1			At base.
	31	10 30	49		W	2			At top.
June	2	8 34		31	E	Slight			
	2	8 30	10		W	Slight			
	3	9 30	75		E		Slight		
	6	8 23		27	W		Slight		
	6	8 18	53		W		1		At base.
	14	8 49		6	E		Slight		At top.
	15	8 36		70	E	Slight			
	15	8 45		52	W		1·5		
	16	9 40		80	E	2			
	19	8 49		36	E		1		At top.
	23	8 26	67		E		Slight		
	23	8 39		3	W		Slight		

The total number of displacements was 213, of which 3 were on the equator and the rest were distributed as follows :—

Latitude.	North.	South.
1°—30°	66	34
31°—60°	47	19
61°—90°	30	14
Total ...	143	67

East limb	126
West limb	86
Pole	1
Total ...	213

One hundred and seventeen displacements were towards the red, 94 towards the violet and 2 both ways simultaneously.

Reversals and displacements on the disc.

One hundred and eighteen bright reversals of the Hα line, 37 dark reversals of the D_3 line and 42 displacements of the Hα line on the disc were observed during the half-year. Their distribution is given below :—

	North.	South.	East.	West.
Bright reversals of Hα	77	41	64	54
Dark reversals of D_3	21	16	22	15
Displacements of Hα	28	14	28	14

Of the displacements, 30 were towards the red, 10 towards the violet and 2 both ways simultaneously.

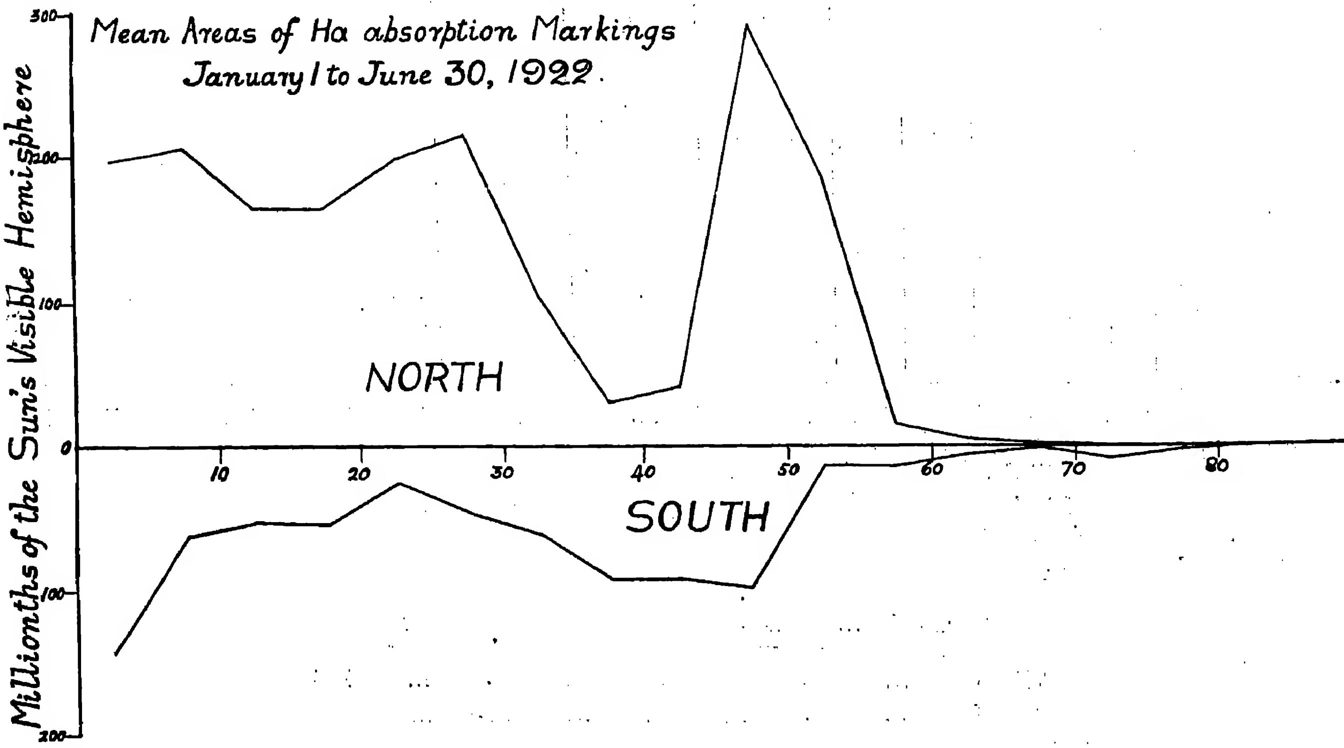
Prominences projected on the disc as absorption markings.

Photographs of the Sun's disc in Hα light were obtained on 98 days counted as 81 effective days. The reduction in the number of days of observation is due to the Hα spectroheliograph having been taken down for improvement during part of January and the whole of February. The mean daily areas in millionths of the Sun's visible hemisphere, corrected for foreshortening, and the mean daily numbers are given below :—

	Areas.	Numbers.
North	1824	13·5
South	768	7·6
Total ...	2592	21·1

Compared with the second half of 1921, there is an increase of 9 per cent in daily areas and a decrease of 5 per cent in daily numbers. The preponderance in activity in the northern hemisphere has now increased to 70 per cent of the total for areas and to 64 per cent for numbers.

The distribution of mean daily areas in latitude is shown in the following diagram:—



The distribution is similar to that for the second half of 1921, but there has been an increase near the quator in both hemispheres. Although there is a decrease in the activity beyond 50° in the southern hemisphere, there is some activity between 70° and 80° in that hemisphere.

There is again a preponderance on the eastern side of the central meridian, amounting to 58·10 per cent of the total for areas and 53·41 per cent for numbers.

THE OBSERVATORY, KODAIKANAL,
5th August 1922.

T. ROYDS,
Assistant Director.

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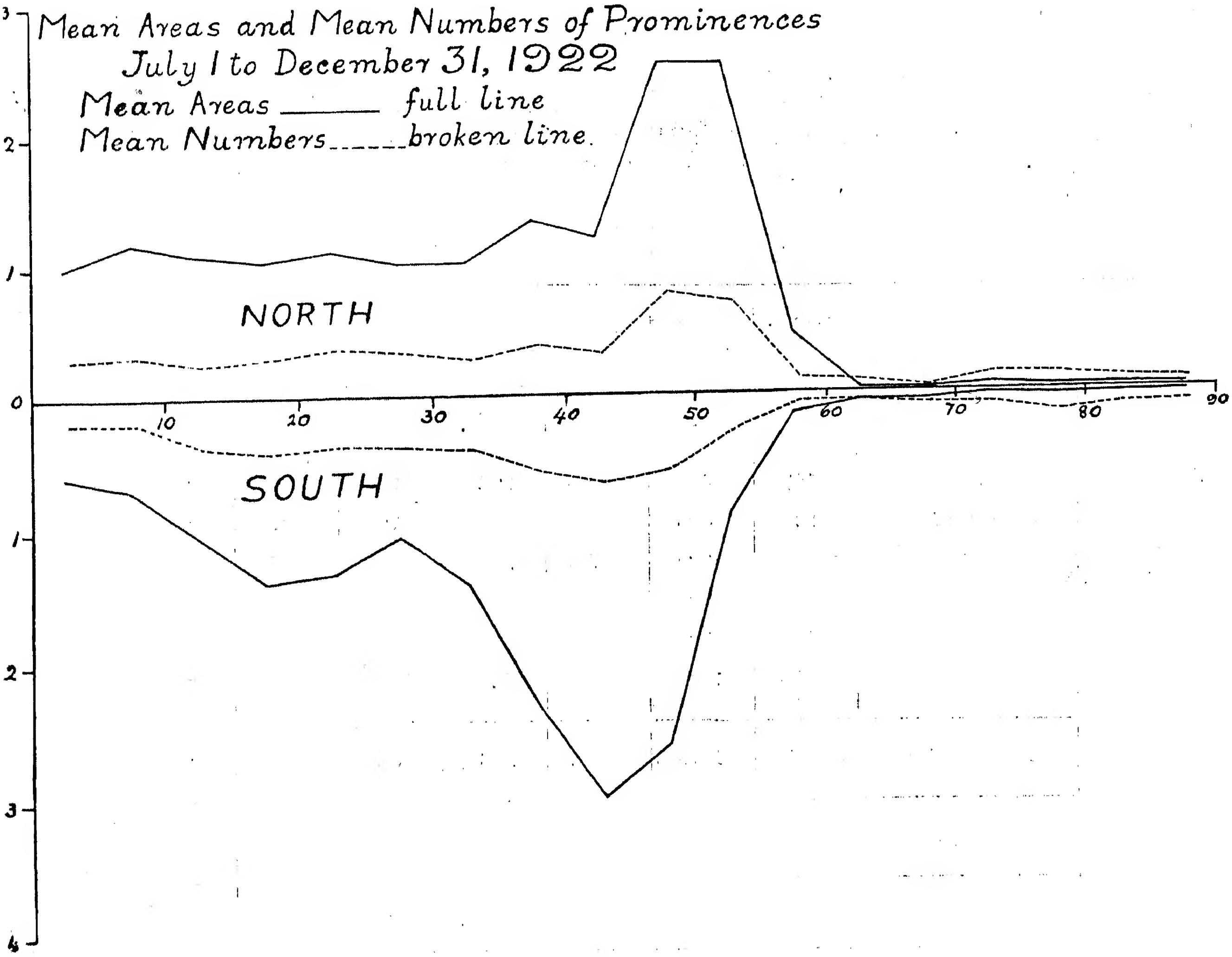
BULLETIN No. LXXI.

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE SECOND HALF OF THE YEAR 1922.

The distribution of prominences observed and photographed during the half-year ending 31st December 1922 is represented in the following diagram, in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude. The ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line. The means are corrected for incomplete or imperfect observations, the total of 138 days being reduced to 123 effective days.



In the northern hemisphere the activity is less than during the first half of the year in all latitudes below 50°, but from 50°—60° the activity is greater resulting in an advance of the zone of maximum activity of 2½° towards the pole. In the southern hemisphere the changes are almost complementary, there being generally an increase in lower latitudes and a decrease from 50° to 60°, the zone of maximum activity having receded 5° towards the equator.

The mean daily areas and numbers corrected for imperfect observations are given below :—

	Mean daily areas (square minutes).	Mean daily numbers.
North	1·58	5·04
South	1·70	5·31
Total ...	3·28	10·35

Areas show a slight increase and numbers a slight decrease on the first half-year. The northern hemisphere has suffered a decrease of about 18 per cent in both areas and numbers whilst the southern shows an increase of 34 per cent in areas and 8 per cent in numbers. This has resulted in the northern preponderance of the first half-year being changed into a slight southern preponderance. The northern prominences were, however, slightly brighter than the southern.

The monthly, quarterly and half-yearly areas and numbers, and the mean height and mean extent of the prominences are given in table I. The unit of area is 1 square minute of arc. The mean height in this and previous bulletins is derived by adding together the greatest heights reached by individual prominences and dividing by the total number of prominences observed; the mean extent is derived by adding together the lengths of the base on the chromosphere of individual prominences and dividing by the total number of prominences observed.

TABLE I.—ABSTRACT FOR THE SECOND HALF OF 1922.

Months.	Number of days (effective).	Areas.	Numbers.	Daily Means.		Mean height.	Mean extent.
				Areas.	Numbers.		
						"	°
July	14½	42·5	143	2·93	9·9	34·6	4·15
August	22	49·5	173	2·25	7·9	34·1	4·22
September	22	64·9	205	2·95	9·3	35·7	4·23
October	19½	50·0	140	2·56	7·2	38·7	3·80
November	16	59·9	155	3·74	9·7	36·4	4·15
December	29	137·2	457	4·74	15·8	31·8	3·58
Third quarter	58½	156·9	521	2·68	8·9	34·9	4·20
Fourth quarter	64½	247·1	752	3·83	11·7	34·6	3·74
Second half-year	123	404·0	1273	3·28	10·4	34·4	3·93

Distribution east and west of the Sun's axis.

Areas show an excess in the eastern hemisphere, but in the case of numbers there is a western preponderance as shown below :—

1922 July to December.	East.	West.	Percentage east.
Total number observed	618	655	48·6
Total areas in square minutes	207·7	196·4	51·4

The average brightness of a prominence was the same on the east limb as on the west.

Metallic prominences.

Metallic prominences were scarce during the half-year only seven being recorded, of which four were observed in the month of December. Details of these prominences are given in the following table :—

TABLE II.—LIST OF METALLIC PROMINENCES OBSERVED AT KODAIKANAL, JULY TO DECEMBER 1922.

Date.		Hour. I.S.T.		Base	Latitude.		Limb.	Height.	Lines.
					North.	South.			
1922		H.	M.	°	°	°		"	
July	15	10	27	1	17·5		W	10	b_1, b_2, b_3, b_4, D_1, D_2.
October	22	8	40			7	W	120	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5316·8, 5328·2, 5363·0, D_1, D_2, 6677.
November	18	8	18	8		12	W	20	b_1, b_2, b_3, b_4, D_1, D_2.
December	2	11	22			15	E	10	b_1, b_2, b_3, b_4, D_1, D_2.
	22	8	56	5	6		E	20	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
	24	9	15	26	15		E	60	b_1, b·, b_3, b_4, 5316·8, D_1, D_2.
	25	9	5	3		4·5	E	25	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.

The distribution in latitude of the metallic prominences was as follows :—

—	1° to 10°	11° to 20°	Mean latitude.	Extreme latitudes.
			°	° °
North	1	2	12·8	6 and 17·5
South	2	2	9·6	4·5 and 15

Four were on the east limb and three on the west.

Displacements of the hydrogen lines.

Particulars of the displacements observed in the chromosphere and prominences are given in the following table :—

TABLE III.—DISPLACEMENTS OF HYDROGEN LINES.

Date.		Time I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1922		H.	M.	°	°		A	A.	A.	
July	3	8	39	33·5		W	1			At top.
	4	9	11		15	E		Slight		
	5	11	40		70·5	W	1			At top.
	25	8	37		28·5	W	Slight			
	26	10	20	21		E	0·5			
	28	8	38		17	W		Slight		
	29	8	35		42·5	E		2		
	29	10	31		3	W	Slight			
	31	8	32	78·5		E	0·5			
	31	8	30	71		E		Slight		At base.
August	4	8	26	75·5		E		Slight		
	7	8	5		43·5	W	Slight			At top.
	8	8	32		83	E	Slight			
	9	8	55	21		E	3			
	9	8	29	28		W	Slight			At top.
	12	9	10		38	W		1		Do
	13	9	1		45·5	W	0·5			Do.
	13	8	55	7		W	Slight			
	14	8	41	81·5		E	0·5			
	14	8	50	41·5		E		Slight		
	16	9	31		15	W	1			At top.
	21	8	35	73·5		W		Slight		
	22	8	41	15		E	Slight			
	25	8	31		19	E		0·5		
	26	9	14		31·5	E		Slight		
	26	9	46	30		W		4		At base.
September	1	8	22	9		W		Slight		At top.
	5	10	10		27·5	W		Slight		
	6	8	22		13·5	E	2			At base.
	10	8	40	32		E		0·5		Do.
	10	8	42	16		E	2			Do.
	10	8	32		70	W	1·5			Do.
	11	8	51	17		W	Slight			
	16	8	46		56·5	E		1		At top.
	18	8	39	33·5		W	1·5			Do.
	18	8	37	79·5		W	0·5			
	19	8	20	51·5		W	1	2		
	20	8	51		69	W		1		
	25	8	24	30		E	1			At base.
October	3	10	0	83		W	1			
	5	8	55	37·5		E	Slight			
	5	8	49		49	W	0·5			
	7	8	58		12	W	Slight			
	9	9	2	50		W		0·5		At base.
	10	8	44		19	E	1			
	10	8	39		79	E		Slight		
	13	8	48	64·5		E		Slight		
	18	9	0		77·5	E		0·5		At base.
	20	9	17	74		E	1			
	22	8	40		5	W	2			
	22	8	40		7	W		1		
	31	10	40		39	E	2			
November	6	8	38	3·5		W	2			
	13	8	41		61	W		0·5		
	13	8	28	74		W	1			
	14	9	30		43	W	0·5			At top.
	18	8	10	42		W		Slight		
	19	8	33		17	W	1			

Date.		Time I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
		H.	M.	°	°		A.	A.	A	
1922 November	20	8	57	48		E		1		At base
	20	8	46		56	W	0·5			
	20	8	43		24·5	W	1·5			
	21	8	44	68		W	0·5			
	22	9	14	86·5		E	2			At top.
	22	8	54	78		E		1		Do
	22	8	43		56	E	0·5			At base.
	24	8	44	43		W		Slight		Do
	24	8	42	60 5		W	Slight			At top
December	2	11	22		15	E	0 5			
	7	9	14		20	E	1			At base.
	7	9	2	50		W	1			
	8	8	50	4		W	2			At top.
	8	8	46	49		W	1			Do.
	8	8	46	47		W	0·5			
	8	8	32	81		W		0·5		At base.
	11	9	8	7		E		Slight		At top.
	11	9	0		85	E	0·5			
	11	8	44		12	W	1			
	11	8	42		1	W		Slight		
	12	9	2	62		E	0·5			In chromosphere
	12	9	2	61		E		1		Do.
	12	9	22	59		W	0·5			
	13	9	11		12	W		3		At base.
	14	8	38	64		E		Slight		Do.
	14	8	35	59		E	Slight			
	14	8	40	78		W		Slight		
	15	8	25	49·5		W		Slight		
	17	8	51		27·5	W	1			
	17	8	46	56		W		Slight		At base.
	17	8	45	80		W	Slight			
	19	8	30		34	W		Slight		
	20	8	54		30	E	0·5			
	21	9	6	20		E	1			At base.
	21	8	46	54		W	1			
	23	8	54	79		E		Slight		At base.
	23	9	7	16		E	1	3		To red at base ; to violet at top.
	24	8	56	6·5		E	3			At base
	25	9	5		4·5	E	1·5	0·5		To red at base ; to violet at top.
	26	9	20	32·5		E	1			At top.
	28	8	27		78 5	E	Slight			

The total number of displacements was only 102 as against 213 in the first half-year. They were distributed as follows :—

Latitude.		North.	South.
1°—30°		17	23
31°—60°		20	12
61°—90°		21	9
	Total ...	58	44

East limb	... ...	47
West limb	... ...	55
	Total ...	102

Sixty-two displacements were towards the red and the rest towards the violet.

Reversals and displacements on the disc.

Thirty-two bright reversals of the Hα line, 6 dark reversals of the D_3 line and 13 displacements of the Hα line on the disc were observed during the half-year. Their distribution is shown below :—

	North.	South.	East.	West.
Bright reversals of Hα	15	17	18	14
Dark reversals of D_3	5	1	3	3
Displacements of Hα	9	4	9	4

Eleven of the displacements were towards the red and 2 towards the violet.

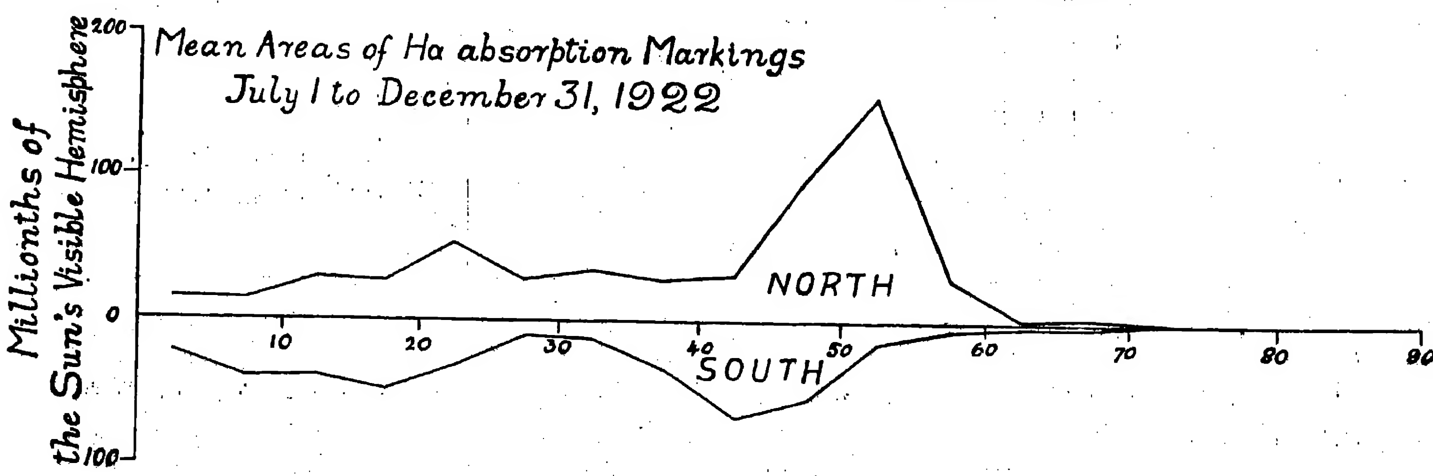
Prominences projected on the disc as absorption markings.

Photographs of the Sun's disc in Hα light were taken on 115 days counted as 94 effective days. The mean daily areas of Hα absorption markings in millionths of the Sun's visible hemisphere, corrected for foreshortening, and the mean daily numbers are given below :—

	Areas.	Numbers.
North	556	5·2
South	368	3·7
Total ...	924	8·9

There has been a great reduction in both areas and numbers amounting to about 65 per cent in the northern hemisphere and 52 per cent in the southern, compared with the previous half-year. Unlike prominences at the limb, the Hα markings still maintain a northern preponderance ; this means that the northern prominences were denser than the southern.

The distribution of the mean daily areas in latitude is shown in the following diagram :—



The diminution of activity is most marked in the region 0°—35° in the northern hemisphere. In both hemispheres the zone of maximum activity has moved 5° towards the equator.

There is again a large excess on the eastern side of the central meridian, the percentage east being 61·38 for areas and 54·46 for numbers.

THE OBSERVATORY, KODAIKANAL,
17th February 1923.

T. ROYDS,
Assistant Director.

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Kodaikanal Observatory.

BULLETIN No. LXXII.

REPORT OF THE INDIAN ECLIPSE EXPEDITION TO WALLAL, WEST AUSTRALIA.

BY J. EVERSHED, F.R.S.

The expedition was organised mainly for the purpose of obtaining photographs of the star-field surrounding the eclipsed Sun, in order to redetermine the deflection of light near the Sun. It appeared to be of great interest and importance to undertake this work because of a certain ambiguity in the results of previous eclipse expeditions, and we had at Kodaikanal a 12-inch photo-visual lens which is particularly well adapted for this problem giving a large field of good definition and a larger scale than the lenses used previously, or that would be likely to be used by other expeditions.

In addition to this work it was proposed to take out a spectrographic outfit and attempt to photograph the spectrum of the corona on the east and west limbs simultaneously, in order to determine the displacements of the green corona line due to the solar rotation, and to get improved values of the wave-length of this line. The results of previous eclipses gave values of the angular rotation in the coronal region largely in excess of the mean values obtained from sunspots and from displacements of lines in the reversing layer, and seemed to indicate a very remarkable law for the angular rotation at different levels; but, owing to the low dispersion hitherto used at eclipses, the values obtained are not very reliable, hence the desirability of repeating the measures with more powerful instruments such as were available at Kodaikanal or could be constructed without much difficulty.

Owing to the proximity of the eclipse track to the south of India, the direct distance from Kodaikanal being less than 600 miles, it was at first proposed to occupy one of the Maldive Islands, and negotiations were entered into with the Surveyor-General of Ceylon, who kindly supplied me with the best information available with regard to these islands. Assuming that transport would be available, application was made to the Government of India through Dr. Gilbert Walker, F.R.S., Director-General of Indian Observatories, for a special grant of money to be supplemented if necessary by private funds which would be available. Professor Raman of Calcutta kindly promised to join the expedition and assist in the work as planned above. I should also have had the assistance of Mr. Bamford of the Colombo Observatory and one or two of the staff at Kodaikanal. Unfortunately for this programme, we underestimated the difficulties of transport from Ceylon to the Islands. Native craft trading between Ceylon and Mali was said to be impossible. The Ceylon Government was approached through the Governor of Madras, who kindly interested himself in our plans, but without avail, and the Government of India, while voting a sum of Rs. 4,500 for the expedition, was unable to provide a vessel suitable for the work. I have to thank Dr. Walker for his great efforts on behalf of the expedition and for his interest in the work generally.

The only alternative to the Maldives which seemed to offer a good chance of success was to occupy a site on the north-west coast of Australia. Negotiations were therefore entered into with the Commonwealth Government, resulting in a cordial invitation to join Dr. Campbell's party at Wallal near Broome. As the funds available would not admit of a large party to Australia, I was compelled to limit the personnel to three only, including myself and Mrs. Evershed. Professor Maclean of Wilson College, Bombay, kindly arranged to join us and assist in the work, but was unfortunately prevented by illness from coming. It then became a serious question whether the expedition should not be abandoned for want of the necessary assistance. In this dilemma, Professor Ross of the University of Western Australia very kindly arranged with the University

authorities to depute Mr. Everson of the Physics Department specially to assist the Indian expedition. I take this opportunity to thank Professor Ross for his efforts on my behalf and the University authorities for lending me Mr. Everson, without whose unflagging energy and efficient aid it would have been impossible to get the instruments erected in time.

CONSTRUCTION AND TESTING OF THE INSTRUMENTS.—A large amount of preliminary construction work was undertaken in the Observatory workshop, beginning about a year before the eclipse date. A large camera box was available, having been originally made for the Indian eclipse of 1898, and this was adapted for the Einstein camera and for taking 12 × 12½ inch plates. A wooden framework covered with metal sheeting was constructed for the tube connecting the camera with the 12-inch lens. A substitute had to be arranged for the lens, as this is in daily use for the two spectroheliographs of the Kodaikanal Observatory. After many trials, I finally used a 9-inch parabolic mirror in combination with a convex mirror arranged as a "Skew Cassegrain" of the type advocated by Dr. Common in 1905. The solar image could be adjusted to have precisely the same diameter as was given by the lens, and the definition of a star-image was quite satisfactory with an aperture reduced to 7 inches. This arrangement was put into operation in December 1921, and the large lens mounted where it could be used for testing the performance of two coelostats and for photographing star-fields.

A polar heliostat by Grubb, not in use, was dismantled and the mirror and declination axis remounted as a coelostat. The Grubb driving clock was modified by adding one gear-wheel to give the correct speed. The mirror of 11-inch aperture when tested at large angles of incidence was found to be far from perfect. I therefore decided to use this coelostat for supplying light to the spectrographs, where the fault would not be of great consequence. A second mirror of 6-inch aperture by Common (also imperfect) was attached to the upper end of the axis to supply light to the second spectrograph.

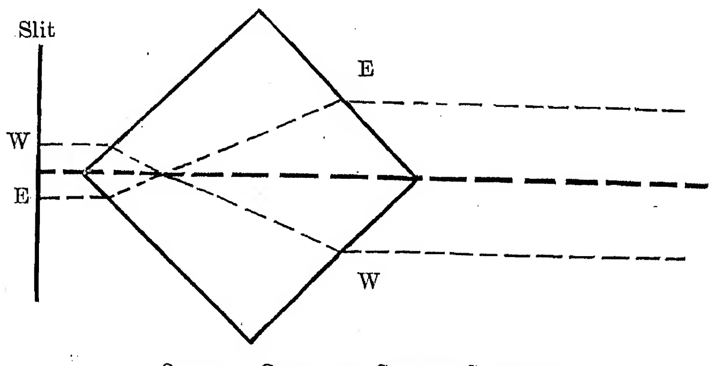
Through the kindness of the Astronomer Royal I obtained the loan of a 16-inch coelostat from the Joint Eclipse Committee of the Royal Society and the Royal Astronomical Society for use with the Einstein camera. Before despatching it, Sir F. Dyson had it tested at the National Physical Laboratory. The report from this Institution was anything but satisfactory both as regards the mirror and the driving mechanism, but as nothing else was available it was sent to Kodaikanal after providing an excellent new driving clock for it by Messrs. Cooke & Sons. As soon as the instrument was received at Kodaikanal in May, it was set up and the uniformity of its movement tested, when it was found that although no appreciable irregularity could be observed with a solar image of about 4 inches diameter, yet when stars were photographed there was shown to be a very marked periodical error, even in the best parts of the sector. Tests were made with the coelostat correctly adjusted in altitude but with the polar axis slightly out of the meridian. In this way by regulating the clock, star images could be made to drift slowly in declination; but instead of this movement appearing on the plate as a straight line of a length proportional to the exposure time, it appeared as a sine curve with a period of one minute, corresponding to one revolution of the driving screw, and with numerous smaller irregularities. As the driving screw was found to be worn and out of truth, and the teeth of the sector injured in many places through the wear and tear of previous eclipse expeditions, it was decided to construct a new screw and refigure the teeth of the driving sector. Fortunately, the Observatory possesses a good screw-cutting lathe, and a new screw was made without much difficulty of the same diameter and pitch as the old screw, also a gun-metal nut rather longer than the screw and cut into four segments accurately clamped together: this was for correcting the screw by Rowland's method of grinding. Many days were spent in grinding and polishing the screw until it was considered to be free from the grosser errors. Next, another similar screw was cut on a length of tool-steel, and ground with the same nut. This was used to re-cut and grind the sector, which was mounted on the slide-rest of the lathe. Finally, the sector was very carefully ground on the first screw. Many difficulties due to inexperience in this work, had to be met and overcome; and it was not until the day of despatch of the cases of instruments to the railway that I was able to complete the work on the sector. Tests of the actual performance of the coelostat had to be deferred until the instruments were re-erected in Australia.

Owing to the bad running of the coelostat, photographs of the eclipse field could not be obtained before leaving for Australia, and it was intended, if satisfactory eclipse plates were secured, to set up the instrument in Madras (latitude 13° north) on our return to India, and get control plates under similar conditions of temperature and focal length, with the star-field in the morning sky, at an altitude of 58° as at Wallal, and at approximately the same hour-angle, but east instead of west.

I proposed to replace the imperfect 16-inch mirror by a 12-inch siderostat mirror by Cooke that was available, but on testing this it was found to be no better than the 16-inch. Either would have given good images near normal incidence, as would have been the case at the station originally selected in the Maldives, but their performance at the Australian station where the angle of incidence was 32½° seemed doubtful. An order was then sent to Messrs. Hilger for a mirror of the largest diameter that could be produced in the limited time available, and a 9-inch of very excellent figure was made, but unfortunately was not received in time for the eclipse.

THE CORONA SPECTROGRAPHS.—The high dispersion auto-collimating prism spectrograph built for photographing Venus spectra was taken to the eclipse without modification, excepting that the small reflecting prisms in front of the slit used for comparison spectra were removed. A second spectrograph was built specially for the eclipse: it is also of the auto-collimating type, but of larger aperture and smaller dispersion. The prisms are of four inches effective aperture and used with a collimator-camera lens of seven feet focus. This gives a dispersion for wave-length 5300 of about 4 angstroms per millimetre, with excellent definition.

As it was desired to photograph both east and west coronal spectra simultaneously, giving an exposure lasting six minutes, both spectrographs were fitted with optical arrangements for bringing the images of the two limbs on to the slit. The simplest way to effect this with little loss of light was to place an optical cube of very transparent glass immediately in front of the slit, a 90° edge of the cube ground and polished perfectly sharp dividing the slit into two equal lengths, as shown in the diagram. The Sun's image after passing through the cube is focussed on the slit, the function of the cube being to split the image into two halves which are reversed on the slit, the east and west limbs facing one another.



OPTICAL CUBE FOR CORONA SPECTROGRAPH.

The size of the cube and the focal length of the image lens are so arranged that there is an interval between the two limbs equivalent to about 10′ of arc In this space the east and west images of the lower corona are formed, the angle of the cube sharply dividing the images at a height of 5′ above each limb. At the base of each corona spectrum it was hoped to photograph point images of the flash spectrum, so that points of known wave-length would be available on either side of the coronal spectra for determining the wave-length of the corona line. This arrangement was applied to the high dispersion spectrograph, with which an image lens of 5 feet focus was used. The second spectrograph was designed to deal with the 4-inch image formed by a lens of 40 feet focus. For this a special apparatus was constructed for reflecting the opposite limbs on to the slit. This consisted of a divided circle bearing reflecting prisms at opposite ends of a diameter, and a silvered right-angle prism mounted at the centre, the sharp edge of this prism bisecting the spectrograph slit and

defining the division between east and west spectra. The circle could be rotated to any position angle, as in similar devices for solar rotation work.

This apparatus was not used at the eclipse, as there was not enough time available before eclipse day to get it into perfect adjustment. The spectrograph was therefore used in an attempt to get a single coronal spectrum image on one limb only.

To avoid trouble with the driving clocks, always liable to occur under the dusty conditions of an eclipse installation, both coelostat clocks were fitted with the double-drive arrangement whereby both ends of the driving rope are attached to the drum and pull in opposite directions, passing over pulleys outside the clock and round the pulley on the weight, which does not rotate but merely serves to equalise the force on the two ends of the rope. The driving force in this way acts as a couple on the drum, instead of the one-sided pull as ordinarily arranged, with half of the weight ineffective in driving the clock. Only one-half of the usual mass is therefore required, unnecessary friction is avoided, and the clock never stops running for any obscure reason. The one disadvantage is that for the same fall the clock only runs for half the time it will go with the ordinary method of drive; but it is easy to arrange for a length of fall sufficient for 45 minutes which is ample for eclipse work.

THE JOURNEY TO WALLAL.—The expedition sailed from Madras on July 28 and arrived at Broome via Singapore on August 18. Here we had to await the arrival of the expeditions from Perth, including the American and Canadian parties. During the ten days' halt I was fortunate in obtaining the use of a workshop and tools, and so was able to construct two large dark slides for the Einstein camera, making five in all. Timber and cement were purchased, and moulds made for the concrete piers that would have to be erected at Wallal. The Resident Magistrate of Broome, Col. Mansbridge, D.S.O., very kindly allowed me to build a pier in his compound for use on our return from the eclipse in an attempt to photograph a high dispersion spectrum of Canopus.

On the 28th of August the various eclipse parties arrived from Perth, and we had the pleasure of meeting Dr. and Mrs. Campbell of the Lick Observatory, Dr. and Mrs. Adams of New Zealand, the members of the Canadian and Australian expeditions, Professor Ross from Perth, and Lieut.-Commander Quick in charge of the naval unit deputed to convey the expedition to Wallal and to form our camp there. The schooner "Gwendolen" hired by the Australian Navy arrived off Wallal on the early morning of the 30th.

ERECTION OF INSTRUMENTS.—Owing to the difficulties of landing some 35 tons by weight of instruments, and getting them up from the shore to the camp, a distance of about a mile, the work of erection could not be fairly started until September 2. During the 18 following days it was all we could do to get the big camera and the two spectrographs erected and adjusted, leaving no sufficient margin of time for rehearsals. A large concrete pier was built for the lens mounting and the 16-inch coelostat, another pier 22 feet to the west of the coelostat for the Einstein camera, and a third pier to the east to carry the smaller coelostat and image lenses for the spectrographs. These piers raised the instruments between 3 and 4 feet above the ground level.

The camera box was bolted to a heavy stone slab cemented to the western pier. The top of this pier and the slab were not made level but inclined 19° downwards towards the north, so that the edges of the plate-holders were 19° out of the vertical. The purpose of this inclination was to get as many of the brighter stars of the eclipse field as possible on to the plates. Had the plates not been inclined in this way, two of the brighter stars would have fallen outside the corners of the 12 × 12½ inch plates.

The wooden mould surrounding the camera pier was not removed when the cement had set, as it was found very convenient for attaching the handle for operating the focussing screw and for fixing two pulleys, one for the cord controlling the coelostat slow motion, and the other for the cord operating the exposing shutter, a large aluminium disc attached inside the connecting tube of the camera about three feet in front of the focal plane.

The accurate adjustment of the camera with respect to the lens was not a very easy matter. The azimuth was computed to be 1° 4′ south of west for the centre of the plates, and this point had also to be arranged precisely level with the centre of the lens. The theodolite attached to the coelostat was found to be too small

and inaccurate to be trusted: I therefore set up in front of the coelostat a good 6-inch Cooke theodolite. With the telescope adjusted level and pointing 1° 4′ south of west I was able to observe the exact point at the camera-end at which the centre of the plate should be placed. The 1-inch theodolite object-glass faced the upper part of the 12-inch lens, thus avoiding the coelostat mirror turned edgewise. The large lens in this way formed a collimator for the theodolite. After fixing this point with certainty, the slide for the plate-holders was secured at the correct position. The coelostat was then adjusted as accurately as possible in altitude, and roughly in azimuth, and finally on the day preceding the eclipse the azimuth was corrected by bringing the Sun's image exactly to its computed position in the field of the camera. Means were provided for accurately adjusting the camera-end so that the plates would be normal to the axis of the lens, the usual squaring-on adjustments of the lens being first manipulated to bring the axis central on the plate. Focussing was effected by movement of the object-glass, the mounting of which was provided with long machined ways and a screw movement.

In order to maintain a fairly uniform temperature, especially inside the camera-tube, the entire apparatus was covered by two large tents, one covering the tube and object-glass, and the other forming a darkened chamber in which the operation of changing the plates could be safely effected. The coelostat was protected as far as possible by a light framework of wood, to which white sheeting was attached. On the day of the eclipse the outer fly of the tents was kept wet until the eclipse itself began to take effect in preventing the great rise of temperature which usually occurred inside the tents during the day.

About a week before the eclipse, tests were made of the performance of the coelostat. The result was that all hope of getting perfect plates had to be abandoned. With the mirror set to the hour-angle at which totality would occur, marked astigmatism appeared in the star-images, and this was due to the faulty figuring of the surface and not to any temporary effect of temperature changes. Another mirror by Cooke of 12 inches diameter had been brought from Kodaikanal in case of accident to the silver surface; but this one as already stated was no better than the 16-inch. A drastic cutting down of the aperture from 12 inches to 6 or 8 inches was the only remedy. In attempting to regulate the driving-clock to give stationary images, it was found that the irregularities previously observed with the old screw were considerably reduced in amplitude, but by no means cured. A star-image would remain apparently stationary for about 20 seconds, and then begin to wander. All attempts to discover the cause of the trouble were unavailing, and one could only hope that plates exposed for less than 20 seconds might with luck give good images, but they could not be expected to show many stars.

Adjustment of the spectrographs.—The high-dispersion spectrograph was placed to the eastward of the smaller coelostat, and the second spectrograph to the westward, the two mirrors of this coelostat being adjustable independently one reflecting east and the other west. Both spectrographs were mounted on packing cases filled with earth, and each was protected by a tent, and by a great mass of non-conducting material packed around the prism chambers. The slit and exposing shutter of the second spectrograph were placed in a convenient position in the main tent which covered the Einstein camera. The adjustment of the prisms and the focussing of these spectrographs was effected with less difficulty than usual, notwithstanding the constant exasperation from innumerable flies attacking one's eyes the moment an observation was attempted.

Operations at the eclipse.—Great care was essential in the final adjustment and focussing of the Einstein camera. The visual and photographic foci had been previously determined and found to be practically identical, but the lens was sensitive to temperature change, and so the focus determined at night would not necessarily be the same during the eclipse. The method adopted for focussing was as follows:—A blank slide with a large opening at the back was fitted with a clear-glass photographic plate (fixed without exposure): this was ruled with fine cross-lines on the film, defining the centre and the direction of right ascension and declination. The crescent Sun about five minutes before second contact was brought to the central position with the south cusp just overlapping the line ruled north and south. Mr. Everson then placed a screen over the object-glass having two apertures, one inch in diameter and eight inches apart, and the cusp was examined with a lens and the focus slightly readjusted from the previously determined focus of stars at night. By this

method, it was estimated that an error of one or two millimetres, or say one part in four thousand of the focal length, would show by a doubling of the sharp cusp, the apertures being placed approximately at right angles to the cusp. Actually a difficulty was experienced in the brilliancy of the light, and much darker shade glasses should have been used to examine it with comfort. After focussing in this way, it was found that by removing the focussing slide and moving a piece of paper across the focal plane the point of coincidence of the two images could be estimated with some accuracy.

After focussing, a dark slide was put in readiness for exposure, and the narrowing crescent which could be seen projected on the slit of the spectrograph was watched, and just before disappearance the signal was given for exposing the two spectrographs ; as these needed no further attention until the end of totality I was able to give undivided attention to the exposure of the five plates of the Einstein camera. There was ample time during the five minutes of totality for changing the slides and operating the five exposures, which had to be short on account of the defects of the coelostat. The exposures varied from five seconds to fifteen seconds duration, the short exposures being made near the beginning and end of totality. Mr. Everson meanwhile changed the aperture over the lens from six inches to eight inches, after the third exposure. The plates used were the fastest I could obtain, the "Stella" brand of Elliott Brothers, Barnet (H. and D. 500). This plate has excellent contrast and fine grain, and has been used very successfully for Venus and star spectra.

I purposely worked deliberately, nevertheless owing to want of sufficient practice in rehearsing a slight mistake was made in the first exposure, and a hitch occurred in the last, the slide being very difficult to close ; in fact it took the whole of the last minute of totality to get the slide safely closed and removed from the camera: I thus lost my chance of getting a good view of the corona with binoculars, as I had intended.

The three middle exposures were operated according to programme, and at the first streak of sunlight the signal was given for closing the spectrograph shutters, one of these being operated by Mr. Everson and the other by Mrs. Evershed, who also took down the times of opening and closing of all the exposures.

All the slides were immediately put safely into bags, and at night the first of the coronal plates and the two spectrograph plates were developed. The coronal plate was not satisfactory, showing a considerable amount of fog and other defects. The spectrograph plates were total failures, the corona line not appearing at all on either of them. This is probably due to the unusual faintness of the radiation at this eclipse, as indicated by photographs taken with low dispersion by Dr. Moore of the Lick Observatory party. The plates used were Ilford Special Rapid Panchromatic.

As the development of the large plates under difficult conditions at Wallal was found to be extremely risky, especially in the drying, the four undeveloped plates were taken from their slides and carefully packed in the tin box in which they had been received, to be developed subsequently at Broome, where ice could be obtained.

When these were developed, however, all were found to have failed for one reason or another. The fifteen seconds exposure plates showed movement of the star images and poor definition of the corona due to the bad driving of the coelostat, and the two short exposure plates in some unexplained way had been badly fogged over two-thirds of the surface, as though the slides had been withdrawn this amount in daylight. The negatives were perfectly clear over the remaining portion where the ends of the coronal streamers appeared beautifully defined. This completed the failure of our eclipse expedition.

A considerable amount of risk is inevitable in all eclipse expeditions, but it is usually associated with the chances of fine weather. Failure under the ideal conditions of a perfectly clear sky, with excellent definition, and a long duration of totality, is deplorable, especially when public funds have been risked.

Notwithstanding the vast amount of trouble and anxiety involved in working the 16-inch coelostat, I am still of opinion that the method is good for the Einstein problem. For only with a coelostat is it practically possible to get an adequate scale. All my experience in measuring the minute displacements of lines in the solar spectrum tends to show that scale is all-important. With insufficient dispersive power there are always large and seemingly inexplicable differences from plate to plate, variations which are at any rate greatly in excess of the probable errors of measurement. The ambiguous result of the measures of star images at

previous eclipses, the displacements varying all the way between the Newtonian and the Einstein law, is a good example of the same difficulty. The question of the coelostat mirror introducing complications is, I think, a bogey. Plane mirrors can now be constructed of large size and perfect figure, and experience with mirrors, good and bad, has shown that little is to be feared from distortion of the surface when the silvering is fresh and good, and simple precautions are taken.

Finally, if British manufacturers could be induced to abandon the old methods and apply ball bearings to all moving parts in astronomical instruments, as should have been done thirty years ago, an enormous gain would result in the uniformity of movement so essential in this research.

Our admiration for the American installation was perhaps tinged with envy. As a matter of course, all polar axes were fitted with ball or roller bearings, and with a simple and most effective method of driving without the use of any gearing whatever. We have great hopes that the excellent plates obtained by Dr. Campbell with his 15-foot cameras will finally yield conclusive evidence as to the amount of the deflection, though we could wish that the focal length had been twice as great.

PHOTOGRAPHING STAR SPECTRA.—Our next work was to set up the 16-inch coelostat and 12-inch lens at Broome, and try to obtain high-dispersion photographs of the spectrum of Canopus under the favourable conditions of the star's high altitude in this southern latitude, and the excellent definition. Mr. Everson again assisted in putting up the instruments, and Dr. Trumpler of the Lick expedition very kindly took a turn at guiding during the long exposures required between midnight and dawn, and he assisted me also in re-silvering the mirror.

The main difficulty encountered was to maintain a constant temperature in the prism chamber, as the diurnal variation was large, and this accounted for a number of failures. We did however succeed in obtaining one good spectrum of Canopus, and also one of the star Achernar ; and these are of great interest in connexion with my previous work on the spectrum of Sirius.

We are very greatly indebted to Col. Mansbridge for his kindness and hospitality during this time : he gave us the free use of his house and compound for this work, which occupied several weeks.

We should like also to refer with gratitude to the welcome we received from the inhabitants of Broome generally, who gave us every assistance and took a keen interest in our work. At their request I gave a public lecture on the Sun, and showed a number of slides illustrating our work at Kodaikanal.

Thanks are also due to the steamship companies who generously carried our three tons cargo of instruments free or at a nominal charge, and to the ships' officers who handled it with scrupulous care.

While at Wallal, we were the guests of the Royal Australian Navy who catered for us generously and provided commodious tents to live in. We wish to thank very heartily Commander Quick and his men for the assistance given us and for their care of our instruments, which were landed at Wallal and brought back to Broome under difficult conditions completely uninjured.

We left Broome on October 24, and reached Kodaikanal on November 20, just missing by one day the weekly steamer from Singapore to Madras.

J. EVERSHED.

THE OBSERVATORY, KODAIKANAL,
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BULLETIN No. LXXIII.

THE EFFECT ON WAVELENGTH IN ARC SPECTRA OF INTRODUCING VARIOUS SUBSTANCES INTO THE ARC.

BY T. ROYDS, D.Sc.

It has been shown by Fabry and Buisson[1] and in Kodaikanal Observatory Bulletins[2] that spectrum lines which are unsymmetrical in width in the electric arc undergo abnormal displacements in the sun when compared with the displacements of symmetrical lines. It has also been shown in Kodaikanal Observatory Bulletins[3] and by others that unsymmetrical lines are displaced under varying conditions in the electric arc, a typical instance being the displacement near the poles of the arc which has commonly been called the "pole effect." Reasons were given in the Kodaikanal Observatory Bulletins referred to for ascribing these displacements of unsymmetrical lines to varying conditions of vapour density although it was stated[4] that for the phrase "density of vapour" that of "density of ions" might have to be substituted. Experiments have now been made and are described in this paper with a view to deciding whether varying density of vapour or of ions is the real cause of displacement of unsymmetrical lines.

2. The method of experiment has been to introduce various substances in turn into the arc giving the spectrum under investigation. It is to be expected that if into a copper arc, for instance, is introduced a substance which is more easily ionised than copper, the density of ions will be increased, whilst the density of copper vapour will probably be reduced (though not necessarily so if the atoms of copper are vaporised in the arc in clusters[5]). The comparative ease of ionisation is, unfortunately, known for only a few substances which are suitable for use in the electric arc. More unfortunately still for our present purpose, the electric arc is a complicated phenomenon whose features are not completely understood ; for instance, the arc voltage is known to vary with the nature of the materials forming the arc but its effect on ionisation is not known ; and again the energy necessary to volatilise different substances from electrodes will influence the energy available for ionisation. Possibly even the temperature of the arc varies with the materials of the electrode which would at once influence the ionisation. So that even if we know that substance A is more easily ionised than substance B, we cannot definitely say whether introducing A into the arc between electrodes of B will increase or decrease the ionisation in the arc. It is, however, practically certain that except by a coincidence of circumstances, the ionisation will be changed, and by trying a variety of substances some may be found to increase the ionisation although perhaps others will decrease it. The method of experiment has therefore been to take various substances which were available and to determine whether introducing them in turn into an arc giving spectrum lines which seemed favourable for study caused any displacement of these lines. The method is consequently not very systematic, and the experiments can only be regarded as

[1] Fabry and Buisson, Astrophysical Journal, 31. 97. 1910.
[2] Kodaikanal Observatory Bulletins, Nos. 38, 53.
[3] " " " Nos. 40, 53
[4] " " " No. 40, page 90.
[5] Royds, Astrophysical Journal, 45. 112. 1917 and Kodaikanal Observatory Bulletin, No. 54, page 195.

explorative, but the displacements were found to be so large as to make it desirable to publish these preliminary experiments before attempting a more systematic investigation.

3. The copper arc was first chosen for study as the lines λλ 4531, 4509, 4480 have been found to be fairly sharp lines requiring short exposures whilst the first and last are sensitive to displacement at the poles of the arc. These three lines are all widened more towards the red than towards the violet, and their displacements at the negative pole of an arc between copper electrodes are + 0·032 A, + 0·014 A, + 0·028 A, respectively. On account of its greater steadiness of burning, the arc for these experiments was between a lower positive electrode of copper and an upper negative electrode of carbon. The arc was always used with a bead of copper on the copper pole. Two electrodes of copper and two of carbon were prepared; one of each was kept uncontaminated from other substances and used to give the comparison spectrum as against the spectrum from the other pair to the copper bead of which had been added the substance whose effect was to be tested. The spectrograph has been described previously[1], the dispersion in this region being about 1·33 mm. to the angstrom.

4. As the effect was found to be greatest when the arc was very short, the results for the arc of length between 1 and 2 millimeters will be given first. The length of the arc was controlled by the length of its image, magnified 3·2 times on the slit plate, care being taken that the arc did not burn into a crater in the carbon or run down the side of the copper bead so as to avoid any false estimate of the true length of the arc. The first half of the exposure of the comparison spectrum was made before and the second half after the spectrum of the arc with substance added. The spectra to be compared were arranged in adjacent strips by means of an occulting shutter which could be moved in front of the slit between the exposures. The current through the arc was about 6 amperes in all the experiments and was kept constant in any experiment to within ¼ ampere. The effects of the following substances were tried :—

(*a*) A small quantity of metallic sodium somewhat smaller than the size of the copper bead on the electrode was added to the copper bead. On striking the arc the sodium burns up into a flame so that it is uncertain how much sodium is left when the arc is brought on to the slit a few moments later, but the arc burns very steadily with the bright yellow light of sodium. The exposure was about 3 minutes compared with 7 seconds without sodium.

(*b*) Iron and aluminium were added to new copper beads in turn. The amount of iron was estimated to be about three times that of the copper, but the exposure required was only half of that when the bead was pure copper.

(*c*) The following salts were added to new copper beads in turn : calcium chloride requiring 2 seconds exposure, sodium carbonate requiring 1 minute, and potassium carbonate requiring 2 minutes.

(*d*) As pure nickel and pure silver were not available, the effect of these metals was tested by comparing copper alloys of these metals with pure copper. These alloys were ready to hand in Indian nickel and silver coins, requiring 2 seconds and 1¼ minutes exposures, respectively.

(*e*) A small quantity of soda glass was melted on to a copper bead and required 1 second exposure only.

The effects of these substances on the wavelengths of the three copper lines studied are given in the following table. The number of photographs on which each value is based is given in brackets.

TABLE I.—MEAN DISPLACEMENTS OF COPPER LINES CAUSED BY INTRODUCING DIFFERENT SUBSTANCES INTO THE ARC.

	Na.	Calcium chloride.	Glass.	Sodium carbonate.	Fe.
4531	+ 0·049A (10)	+ 0·035A (4)	+ 0·032A (3)	+ 0·025A (6)	+ 0·016A (5)
4509	+ 0·018A (3)	+ 0·012A (6)	+ 0·010A (3)	+ 0·006A (6)	+ 0·004A (3)
4480				+ 0·022A (6)	

[1] Evershed, Kodaikanal Observatory Bulletin, No. 36.

	Ag.	Al.	Ni.	Potass. carbonate.
4531	+ 0·015A (5)	+ 0·014A (3)	+ 0·009A (8)	+ 0·006A (6)
4509	+ 0·009A (5)	+ 0·004A (3)	+ 0·002A (8)	+ 0·002A (6)
4480				+ 0·005A (6)

It is not to be expected that very consistent values will be obtained in each experiment owing to the impossibility of introducing exactly the same amount of material in different experiments and owing to the fact that the arc was very short. Table II has therefore been given to show the actual displacements observed in each experiment for the line λ 4531 :

TABLE II.—DISPLACEMENTS OF THE CU LINE 4531 IN EACH INDIVIDUAL EXPERIMENT.

Experiment No.	Na.	Calcium chloride.	Glass.	Sodium carbonate.	Fe.	Ag.
1	+ 0·040A	+ 0·043A	+ 0·025A	+ 0·005A	+ 0·016A	+ 0·017A
2	+ 0·021	+ 0·031	+ 0·041	+ 0·015	+ 0·017	+ 0·011
3	+ 0·096	+ 0·025	+ 0·030	+ 0·032		+ 0·020
4	+ 0·101	+ 0·040		+ 0·026		+ 0·014
5	+ 0·043			+ 0·037		+ 0·013
6	+ 0·055			+ 0·033		
7	+ 0·062					
8	+ 0·042					
9	+ 0·005					
10	+ 0·022					
Mean	+ 0·049	+ 0·035	+ 0·032	+ 0·025	+ 0·016	+ 0·015

Experiment No.	Al.	Ni.	Potass. carbonate.
1	+0·011A	+0·014A	−0·004A
2	+0·016	+0·007	+0·008
3	+0·015	+0·011	+0·023
4		+0·006	−0·006
5		+0·024	+0·009
6		−0·001	+0·003
7		+0·010	
8		0·000	
Mean	+0·014	+0·009	+0·006

It seems surprising that the addition of certain substances should reduce the exposure required for the copper lines. If it be argued that the short exposure is a consequence of increased vapour density, vapour density cannot be the controlling factor since the addition of soda glass which shortens the exposure to 1 second has an effect of the same sign as the addition of metallic Na, which lengthens the exposure to 3 minutes.

5. The following evidence is given as proof that the displacements observed are real and correctly interpreted as due to the addition of substances into the arc :—

(*a*) By the practice of giving half the exposure of the comparison spectrum before and after the spectrum under test the presence of spurious displacements such as those caused by temperature changes during the experiment would have been detected. Moreover, it is unlikely that temperature changes during the short exposures required could be appreciable. The absence of displacements of this kind is, however, proved by the fact that the displacements vary from line to line, depending only on the unsymmetrical character of the lines, and as will be seen later, symmetrical lines have zero displacement.

(*b*) Apparent displacements of unsymmetrically widened lines can be produced by overexposing one of the two spectra under comparison the displacement being in the direction of the greater widening. These apparent displacements can only be avoided by giving a minimum exposure to each spectrum so that the exact position of greatest density in the spectrum line is not obliterated by overexposure. In these experiments the best exposure was tried out before photographs for measurement were taken, and no plates were measured in which there was a danger of error through overexposure.

(*c*) The displacements are really due to the introduction of another substance into the arc and not to any other previously known cause. It was previously known that these three copper lines λλ 4531, 4509, 4480, will be displaced towards the red (1) at the poles of the arc, (2) with increased current and (3) with decreased length of the arc. Many of the displacements observed are much greater than any possible displacement due to such causes. Firstly, the displacement of the line λ4531 at the negative pole of the very short arc (1 to 2 mm.) between Cu positive and C negative is only + 0·001A, at the positive pole +0·002A : secondly, the current can easily be kept constant to within $\frac{1}{4}$ ampere ; and thirdly although there may be some difficulty in maintaining very short arcs absolutely ~~constant in length, the~~ variations in length in any experiment was many times less than the change from $1\frac{3}{4}$ mm. to 4 mm. which caused a displacement of 4531 of + 0·012A : the displacement due to any variations in length of arc during any experiment must therefore have been considerably less than this.

(*d*) Control experiments were also made to verify the reality of the displacements and to test the effect of any probable variations in the arc conditions. The exact procedure adopted in testing the effect of any substance was followed except that no substance was introduced. The measured displacement in the control experiments never exceeded 0·003A, the mean being + 0·001A.

6. It is seen from Table I that the displacement of the more unsymmetrical lines 4531, 4480 is greater than that of the less unsymmetrical line 4509. There are no symmetrical copper lines in the same region of the spectrum to test whether they would be displaced or not. The symmetrical lines of iron in this region were therefore used for the test. A bead composed of a mixture of copper and iron on the positive pole gave the lines of both metals simultaneously and its spectrum was compared with that using a similar bead into which metallic sodium had been added. The copper lines, presumably already displaced by the presence of iron as shown in Table I, were further displaced by adding sodium by + 0·069 A, + 0·013A, +0·055A (mean of 2 photographs) for the lines 4531, 4509 and 4480, respectively, whilst the mean displacement of the 3 symmetrical iron lines 4528, 4494, 4466 was + 0·0003A.

7. The effect of introducing substances into the long arc is very much smaller, even at the poles, than the effect in the short arc. When metallic sodium is added to the copper bead on the positive pole, the length of the arc being 10 mm., the displacement was only + 0·004A (mean of 4 determinations) when comparing the region near the positive pole in each arc. The case of the displacement at the centre of the long arc due to the introduction of substances is of great practical importance because many wavelength determinations in the past have been made from the centre of the long arc without, in many cases, account being taken of the presence of other substances in the arc. The displacement at the centre of an arc 10 mm. long when glass was melted into the copper bead was + 0·001A, the mean of 5 determinations, which although too few to establish the reality of so small a displacement, suffice to show the order of magnitude for this line. It is clear that the effect is small unless a spectrum line is more sensitive than the copper line 4531.

8. We may thus summarize the results for the copper lines. Under suitable conditions the unsymmetrical lines of copper may undergo large displacements in the direction of their greater widening as a result of introducing other substances into the arc. If the view that the displacements are due to a change in ionisation in the arc as a result of introducing substances into the arc is correct, it follows that all the substances, chosen more or less at random, whose effect on copper was tried, increased the ionisation in the arc.

9. Experiments with copper lines having given positive results, similar experiments were tried with the ca cium triplet λλ 4586, 4581, 4578, which, although widened more unsymmetrically towards the red than the

copperr lines first chosen, are less easy to measure accurately. The calcium comparison spectrum was produced by an arc between a commercial flame arc carbon as positive pole, and a plain ordinary carbon as negative. It was considered that this would give more constant conditions than would be possible by introducing a calcium salt into a carbon arc. The tests for the effect of other substances were carried out with an exactly similar pair of carbons, the substances being placed into the crater of the flame carbon. When the arc is very short the edge of this crater prevents any light from reaching the spectrograph. A longer arc was therefore used than in the case of the copper arc, and these experiments were carried out with an arc 4 mm. in length, the current strength being 3 amperes. The results for calcium are not as consistent as one would like, but this is attributed mainly to inconstancy of the arc conditions owing to the wandering of the arc over the positive pole in which were situated irregularly globules of calcium material and of the substance introduced. Table III shows the mean displacements for the different lines of the triplet and Table IV shows individual values for the line 4586.

TABLE III.—MEAN DISPLACEMENTS OF CALCIUM LINES CAUSED BY INTRODUCING DIFFERENT SUBSTANCES INTO THE ARC.

—	Cu.	Glass.	Fe.	Silver coin.	Nickel coin.
4586	+0·002A (7)	−0·002A (6)	−0·005A (3)	−0·012A (5)	−0·020A (5)
4581	+0 002A (5)	0·000A 6)	−0·006A (3)	−0·012A (5)	−0·022A (5)
4578	+0 002A (1	−0·002A (5)	−0·005A (2)	−0·014A (5)	−0·020A (5)

TABLE IV.—DISPLACEMENTS OF THE CA LINE 4586 IN EACH INDIVIDUAL EXPERIMENT.

Experiment number.	Cu.	Glass.	Fe.	Silver coin.	Nickel coin.
1	+0 005A	+0·017A	−0·007A	−0·008A	−0·006A
2	−0·005	−0·011	−0·003	−0·017	—0·036
3	−0 001	−0·009	−0·004	−0·014	−0 028
4	+0 001	0·000	...	−0·011	−0 012
5	−0·001	−0·005	...	−0 012	−0·019
6	+0·009	−0·007	...	...	...
Mean.	+0·002A	−0·002A	−0·005A	−0·012A	−0·020A

The following observations were also made, although not in very good agreement with those in Table III ;—taking the arc with copper added as standard, replacing the copper by iron caused displacements of — 0·016A, — 0·016A, — 0·014A for the 3 lines of the Ca triplet, and replacing the copper by nickel coin caused displacements of — 0·009A, — 0·008A, — 0·010A.

Using a flame arc carbon as negative pole and taking the arc with a positive pole of copper as standard, making the positive pole iron caused displacements of — 0·008A, — 0·008A, — 0·010A for the 3 lines of the Ca triplet.

10. The displacements of the calcium triplet being principally negative, they are not by themselves conclusive as to whether the displacements are due to a reduction of vapour density or to other causes such as a reduction of ionisation in the arc. The displacements of the copper lines being positive, can, however, be definitely said not to be due to an increase in the vapour density, and are attributed in this paper, largely on account of the rational explanation which will be developed §§ 11–13, to an increase in the ionisation in the arc.

11. Stark[1] has suggested that the widening of the spectrum lines emitted by a radiating atom is caused by the electrical field exerted by surrounding atoms. He has shown that in general a spectrum line emitted

[1] Stark, quoted by Fulcher, Astrophysical Journal, 41, 359, 1915.

by a gas in an electrical field of definite value is split up into a number of components. Since a radiating gas will be partially ionised, each radiating atom will find itself in an electric field which will not have the same value for all atoms, and the average effect will be a broadening of the spectrum lines. Stark has pointed out that spectrum lines broaden symmetrically or unsymmetrically according as whether the resolution in an electrical field is symmetrical or unsymmetrical. It is obvious that the displacements of unsymmetrical lines under different conditions of the electric arc as described in this and previous Bulletins and by others, as well as their abnormal displacements in the sun can also be interpreted by their unsymmetrical resolution in an electric field. The evidence which has been given by Takamine[1] also confirms the intimate relation between the Stark effect in electric fields and the displacements of unsymmetrical lines near the poles of the arc. There can now be no doubt that the displacements and broadening of unsymmetrical lines find a ready explanation as an effect of an electric field.

12. A further confirmation of this is furnished by the change in the character of lines of certain spectrum series. It was shown[2] that in the first subordinate series of barium the second members are unsymmetrically widened towards the red, whilst succeeding members are unsymmetrical towards the violet, but the Stark effect for this metal is not available. For copper and silver, however, Takamine[3] has shown that the direction of displacement in an electric field is not the same for the different members of the subordinate series. It is found that the unsymmetrical character and pole effect correspond closely with the behaviour in an electric field, as is seen from Table V, where v denotes towards the violet and r towards the red. The correspondence is not exact; e.g., the copper pair 3861, 3825 are not definitely unsymmetrical in the arc and their negative pole displacement seems to be slightly to the red (+ 0·003A) although they are difficult to measure; certain it is, however, that they are less unsymmetrical towards the red and less displaced than the pair 4531, 4480, whereas in the general run of series they would be more unsymmetrical and more displaced.

TABLE V.—RELATION OF THE UNSYMMETRICAL CHARACTER AND POLE EFFECT OF CERTAIN SERIES LINES TO THEIR BEHAVIOUR IN AN ELECTRIC FIELD.

Series.	Line.	Displacement in electric field.	Unsymmetrical character.	Displacement at negative pole of arc.
Cu I N.S.	5220	v	v	......
	5218	v	v	......
	5153	v	v	......
	4063	r	r	r
	4062	r	r	r
	4022	r	r	r
	3688*	r	r	r
	3654	r	r	r
Cu II N.S.	4531	r	r	r
	4480	r	r	r
	3861	v	doubtful	r?
	3825	v	doubtful	r?
Ag I N.S.	5471	......	v	......
	5465	......	v	......
	5209	......	v	......
	4212	r	r	r
	4210	v	v	v
	4055†	r (v)	r (v)	r (v)
	3810‡	v	v	v
	3682	v	v	v

[1] Takamine, Astrophysical Journal, 50, 53, 1919.
[2] Royds, Astrophysical Journal, 41, 154, 1915 and K.O. Bulletin No. 43.
[3] Takamine, l.c.

* The Cu line 3688 has a faint companion in the arc in air, apparently corresponding to the 4063 line.
† The Ag line 4055 requires investigation; it is probably a double line. See paragraph 13.
‡ The Ag line 3810 has a faint companion apparently corresponding to the 4212 line. According to Takamine the separation is 0·86A.

13. We have evidence that electric fields are operating in the electric arc from the fact that lines which are faint or absent in the discharge in vacuo and appear strong only in an electric field are present in the spectrum of the arc in air. This has not been very thoroughly tested here, but it has been found that Ni lines given by Takamine, though not appearing in the published arc spectra of Ni, such as the line 4037·7, are actually present in the arc spectrum. The best instance appears to be a silver line near 4055. Kayser and Runge give two silver lines 4211 and 4055 as reversed in the arc. Liveing and Dewar, and also Eder and Valenta[1] have shown that 4211 is not a reversed line but two separate unreversed lines, which is apparently confirmed by the arc in vacuo. The same tests on the arc in air which show 4211 to be two lines will show that 4055 is also two unreversed lines, the more refrangible of which is unsymmetrical towards the red and the less refrangible unsymmetrical towards the violet: indeed, they are very similar to the 4211 pair, but closer together.[2] The reason why the published spectra of the arc in vacuo give only a single line at 4055 becomes clear from the photographs of Takamine in which it is seen that the less refrangible line only appears in an electric field. It should be pointed out that according to the wavelength measurements made here it is the more refrangible component of the 4055 pair which belongs to the first subordinate series, the less refrangible apparently belonging to the combination series which is nearly coincident with the former.

14. Interpreting the displacements of unsymmetrical lines in the sun and arc as due to electric fields, we can proceed to find the magnitudes of the average electric fields which are causing the displacements. Different lines in the same spectrum do not, however, lead to the same value for the electric field, possibly because of the assumption that the effect in an electric field is proportionate to the field strength. There can be no doubt, for instance, that the displacements of the Cu pair 4531, 4480, under different conditions of the electric arc are practically equal, whereas Takamine gives them as displaced by an electric field of 44,000 volts/cm by + 0·035A and + 0·100A, respectively. Assuming proportionality to field strength and taking the displacements at the negative pole given in paragraph 3, viz., + 0·032 A, + 0·028 A, these two Cu lines give for the field operating at the negative pole of a copper arc the very large and inconsistent values of 40,300 volts/cm and 15,700 volts/cm, respectively, greater than the field operating at the centre of the arc. Other elements give smaller and more consistent values. Taking the negative pole displacements given in previous bulletins for all the elements for which Takamine has given the Stark effect, we find the following values for the electric field at the negative pole in excess of that at the centre of the arc:—Fe (6 lines) 5,970 volts/cm, Na (2 lines) 4,575 volts/cm, Ni (4 lines) 3,380 volts/cm. Similarly, taking the solar displacements of the unsymmetrical lines of Fe, Na, and Ni from Kodaikanal Observatory Bulletins, and making an allowance for the Doppler shift as deduced from the symmetrical lines at the same depth in the sun, we find that the electric field in the sun is less than that at the centre of the electric arc by the following amounts:—Fe (3 lines) 2,420 volts/cm, Na (2 lines) 1,870 volts/cm, Ni (11 lines) 2,300 volts/cm. We may therefore take it that the field at the negative pole is of the order of 4,000 volts/cm greater than that at the centre of the arc, whilst the field in the sun is of the order of 2,000 volts/cm less than that at the centre of the arc.

15. It can easily be shown that fields of this order of magnitude can be accounted for by the field exerted by surrounding atoms. Debye[3] has calculated the average electric field due to ionisation, assuming that it depends only on the number of ions and the ionic charge, and finds the law that the field is proportional to (ionic charge) $\times$ (number of ions per c.c.)$^{\frac{2}{3}}$. The average electric field in which an atom finds itself when a gas at N.T.P., is completely ionised he gives as being of the order of 1,350,000 volts/cm. At 4000° K, the temperature of the arc, this becomes 225,000 volts/cm, and at 6000° K, the temperature of the sun, and atmospheric pressure it is 172,000 volts/cm.

16. If our knowledge of the conditions obtaining in the arc were complete we should now be in a position to make deductions concerning conditions in the sun. Making reasonable assumptions regarding the ionisation

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[1] See Eder and Valenta, Denksch. Wien. Akad. 63, 189, 1896 and Beitrage zur Photochemie, page 161.
[2] Pure silver was not available for these tests. Silver coins were used but it was ascertained that no copper lines nor ghosts of copper lines could be interfering.
[3] Debye, Phys. Zeitschr. 20, 160, 1919.

in the arc does not, however, lead to results which are plausible. From the work of Saha an ionisation in the arc of 1 per cent is not unreasonably large, but it leads to a field of 10,000 volts/cm at which field strength many lines ought to be several angstroms wide, but are in fact fairly sharp. It appears probable that Debye's law given in the previous paragraph is incorrect. It is difficult to believe that the field due to ions which are frequently colliding with atoms can be independent of their diameters and of the frequency of collision, and unless their independence can be established Debye's law falls to the ground. If a given mass of radiating gas, for example, were heated at constant volume and constant ionisation (controlled, say, from outside), the pressure would rise and we should expect a shift due to pressure, but according to Debye there would be no change in the average field strength and therefore, in the light of paragraph 17, no pressure shift. Moreover, the most firmly established law of pressure shifts is that of direct proportionality to pressure, whereas Debye's law requires proportionality to the $\frac{2}{3}$rds power of the pressure.

17. An important point is the ultimate cause of pressure shifts, Stark having suggested that asymmetry in an electric field is the cause. Here again, different lines in the same spectrum do not give consistent values for the field strength; e.g., the copper line 4063 requires nearly 3,000 volts/cm per atmosphere increase of pressure, whilst 4531 requires 28,000 volts/cm per atmosphere. Unless the direction of displacement under pressure follows that of the asymmetry in an electric field, we can at once dismiss the Stark effect as a possible cause of pressure shifts. It is true that lines which are unsymmetrically resolved or displaced towards the red in an electric field have large pressure shifts, and that lines which are symmetrical in the arc have such small pressure shifts that the corresponding displacement or asymmetry in an electric field may not be detectable, but the situation as regards lines which are unsymmetrically widened towards the violet in the arc and are unsymmetrically resolved or displaced towards the violet in an electric field is not so satisfactory. For, whilst Gale and Adams[1] for Fe, Duffield[2] for Ni and Miller[3] for Ca have found that lines unsymmetrical towards the violet are displaced to the violet by pressure, Humphreys[4] has many examples of such lines being displaced to the red; e.g., Ca triplet and satellites at 4456,35,25, Cu doublet and satellite 5220, 5218, 5153, Mg triplet 3838, 32, 29, Ni line 5155, Sr triplet and satellites 4971, 4876, 4832. These discrepancies require careful investigation.

18. Nevertheless, an obscure feature of pressure shifts can be readily explained on the hypothesis of the Stark effect. Pressure displacements in the furnace and in the spark are greater than in the arc whilst the widening is also greater in these sources. Since the greater widening is very probably a Stark effect, so presumably would the greater pressure shift, both being due on the interpretation given in this paper to greater ionisation in the furnance and in the spark under pressure.

19. King explains[5] the asymmetry and displacements of lines in the arc, tube-arc, and spark as due to the density of high speed electrons. I consider that the suggestion made in this paper that these effects are due to the electrical field in which the radiating atom finds itself offers a more rational, though not necessarily inconsistent, explanation. King shows that under the extreme conditions of the tube-arc nearly all lines show as unsymmetrical, even certain "flame" lines of iron. It would appear, therefore, that the difference between unsymmetrical lines and those which have generally been referred to as symmetrical is mainly one of degree; this is required if the explanation of pressure shifts in paragraph 17 is correct, although again there is the inconsistency of the H and K lines of Ca which King finds to be slightly unsymmetrical towards the violet being, as he points out, displaced to the red under pressure.

20. If the view expressed in this paper is correct that asymmetry and displacements are effects of the electric field due to ionisation of the gas, then since ionisation increases with temperature so should also the asymmetry and displacement of spectrum lines. As passing from the arc to the sun shows an opposite effect

[1] Gale and Adams, Astrophysical Journal, 37, 391, 1919.

[2] Duffield, Phil. Trans. R.S. 215, 205, 1915.

[3] Miller, Astrophysical Journal, 53, 224, 1921.

[4] Humphreys, Astrophysical Journal, 6, 169, 1897. See also Humphreys on *Pressure shift of violet sided lines*, Astrophysical Journal, 31, 459, 1910.

[5] King, Astrophysical Journal, 41, 373, 1915.

it would follow that the fall in density more than counterbalances the rise in temperature and denotes that the partial pressure of ions is less in the sun than in the arc. It is to be expected, however, that there will be a displacement of unsymmetrical lines in sunspots relative to the photosphere where the temperature is higher, but the magnitude of the displacement cannot yet be predicted from theory.

21. Suitable lines unsymmetrical towards the violet were not readily available in this preliminary study of the effect of adding substances into the arc, but it is desirable to confirm the expectation that they will be displaced in the opposite sense to lines unsymmetrical towards the red.

Summary.—1. These experiments were undertaken with a view to deciding whether density of vapour or density of ions is the cause of the displacements of unsymmetrical lines under varying arc conditions.

2. In a short arc certain lines of copper which are unsymmetrically widened towards the red are displaced to the red by introducing various substances into the arc; the less unsymmetrical lines undergo smaller displacement, and symmetrical lines are not displaced at all.

3. The effect is smaller at the poles of a long arc and insignificant at the centre of a long arc for the lines studied.

4. In a calcium arc lines unsymmetrical towards the red are shifted slightly towards the red, or towards the violet according to the substance introduced.

5. It is suggested that these displacements are caused by changes in the ionisation in the arc when extraneous substances are introduced into the arc.

6. There is now considerable evidence that the asymmetry and displacement of lines under varying arc conditions and their abnormal displacement in the sun follow very closely their asymmetry and displacement in an electric field. The electric field operating in the arc and the sun is probably the intermolecular field due to surrounding ions and electrons. On this view the average electric field at the negative pole of the arc is of the order of 4000 volts/cm greater than that at the centre of the arc and in the sun 2,000 volts/cm less than at the centre of the arc. Until the ionisation in the arc is investigated and the average electric field due to ions has been satisfactorily worked out we are unable to apply these data to the determination of the partial pressure of ions in the sun.

7. The view that there are electric fields in the arc is supported by the presence in arc spectra of those lines which in the vacuum arc are only in evidence in a strong electrical field.

8. Although many features of pressure displacements can be explained as due to the increase in the intermolecular electrical fields owing to the increase in the partial pressure of ions, there are some difficulties. The point which first requires experimental elucidation is the direction of the pressure shift of lines unsymmetrical towards the violet concerning which evidence is contradictory.

9. Further examples have been found of series in which the character of the lines reverses as we pass down the series.

This work was carried out whilst Mr. Evershed was still Director, and it is a pleasure to acknowledge my indebtedness to his interest and suggestions.

THE OBSERVATORY, KODAIKANAL,
14th April 1923.

T. ROYDS,
Director,
Kodaikanal and Madras Observatories.

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BULLETIN No. LXXIV.

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE FIRST HALF OF THE YEAR 1923.

In accordance with a resolution of the International Astronomical Union meeting held in Rome in 1922, the Kodaikanal Observatory has undertaken the work of compilation and discussion of statistics derived from photographs of prominences and Hα absorption markings of the Sun. All observatories taking prominence and Hα spectroheliograms of the Sun have been asked to co-opearte by supplying copies of their photographs on those days when the Kodaikanal record is imperfect or wanting. In response to our requirements, the Mount Wilson Observatory sent prominence plates in calcium K light for 34 days in the half-year and Hα disc plates for 20 days ; Meudon Observatory sent K_3 disc plates for 24 days and Hα disc plates for 14 days ; no plates were asked for from the Yerkes Observatory where calcium H_2 disc plates and prominence plates are occasionally taken.

When incomplete or imperfect photographs from more than one observatory are available for the same day, the best photograph is chosen as representing the solar activity of that day after weighting the plate according to its quality, and the remaining photographs are ignored.

The mean daily areas and numbers are given below. The means are corrected for incomplete or imperfect observations, the total of 176 days for which photographs are available being reduced to 160½ effective days.

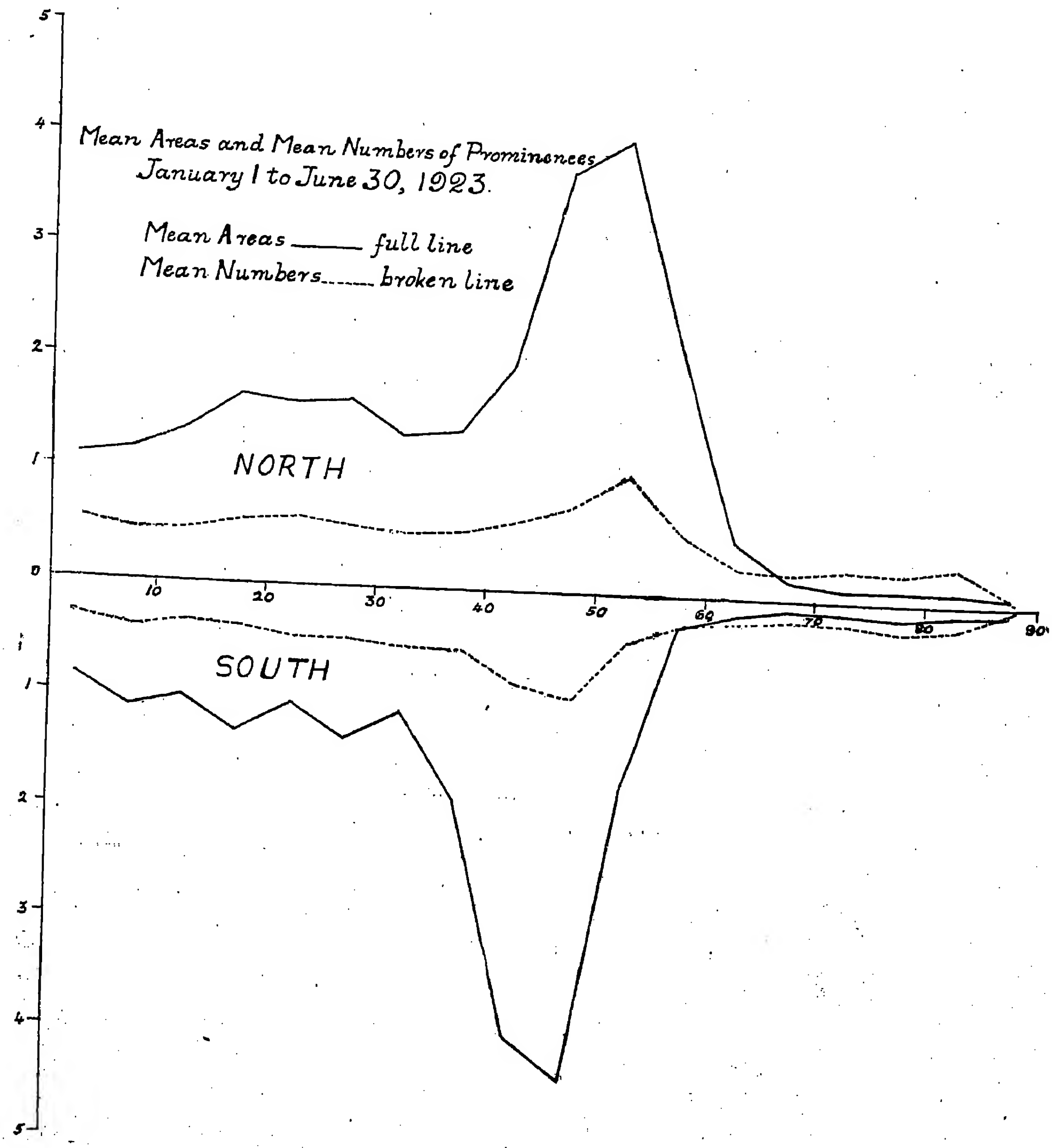
	Mean daily areas (square minutes).	Mean daily numbers.
North	2·43	8·37
South	2·06	7·13
Total ...	4·49	15·50

For comparison with previous bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 164 days being counted as 152½ effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North (Kodaikanal photographs only)	2·48	8·56
South do.	2·10	7·33
Total ...	4·58	15·89

Compared with the previous half-year areas show an increase of 57 per cent in the northern hemisphere and 24 per cent in the southern. In the case of numbers there is an increase of 70 per cent in the northern hemisphere and of 38 per cent in the southern.

The latitude distribution of prominences on photographs from all the co-operating observatories during the half-year ending 30th June 1923 is represented in the accompanying diagram in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude. The ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line. The curve is similar to the distribution in the second half of 1922 except that there is greater activity in the higher latitudes and a slight advance towards the poles.



The monthly, quarterly and half-yearly areas and numbers, and the mean height and mean extent of the prominences on photographs from all the co-operating observatories are given in Table I. The unit of area is 1 square minute of arc. The mean height is derived by adding together the greatest heights reached by individual prominences and dividing by the total number of prominences observed; the mean extent

is derived by adding together the lengths of the base on the chromosphere of individual prominences and dividing by the total number of prominences.

TABLE I.—ABSTRACT FOR THE FIRST HALF OF 1923.

Months.	Number of days (effective).	Areas.	Numbers.	Daily Means.		Mean height.	Mean extent.
				Areas.	Numbers.		
						″	°
January	26	124·0	449	4·8	17·3	31·9	3·45
February	28	140·0	471	5·0	16·8	33·5	3·86
March	27	122·8	435	4·6	16·1	33·2	3·38
April	27½	130·7	436	4·8	16·8	35·2	5·76
May	28¾	116·7	411	4·1	14·3	33·2	3·32
June	23¼	87·2	285	3·8	12·2	34·4	3·73
First quarter	81	386·8	1355	4·8	16·7	32·9	3·57
Second quarter	79½	334·6	1132	4·2	14·3	34·3	4·36
First half-year	160½	721·4	2487	4·5	15·5	33·6	3·93

Distribution east and west of the Sun's axis.

Both areas and numbers show an excess in the western hemisphere as will be seen from the following table :—

1923 January to June.	East.	West.	Percentage East.
Total number observed	1229	1258	49·4
Total areas in square minutes	345·8	375·6	47·9

Metallic prominences.

Only six metallic prominences were recorded during the half-year.

All of them were on the west limb and their details are shown below :—

TABLE II.—LIST OF METALLIC PROMINENCES OBSERVED AT KODAIKANAL, JANUARY TO JUNE 1923.

Date.		Time I.S.T.	Base.	Latitude.		Limb.	Height.	Lines.
				North.	South.			
1923		H. M.	°	°	°		″	
January	5	8 45	1	11·5		W	15	b_1, b_2, b_3, b_4, 5316·8, 5535·06, D_1, D_2, 6677.
	8	8 52	2		3	W	10	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5208·7, 5276·2, 5316·8, D_1, D_2, 7065.
	31	9 19	19	10·5		W	65	b_1, b_2, b_3, b_4, D_1, D_2.
February	1	9 12	27	18·5		W	65	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5316·8, 5363·0, D_1, D_2, 6677, 7065.
	2	8 54	15	18·5		W	80	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5316·8, D_1, D_2.
	14	9 23			0·5	W	40	4922·0, 4924·1, 5018·6, b_1, b_2, b_3, b_4, 5197·8, 5234·8, 5276·2, 5316·8, 5363·0, 5535·06, D_1, D_2, 6677, 7065.

The distribution in latitude of the metallic prominences was as follows :—

—	1° – 10°.	11° – 20°.	Mean latitude.	Extreme latitudes.
North	...	4	14°·8	10°·5 and 18°·5
South	2	...	1°·8	0°·5 and 3°

Displacements of the hydrogen lines.

Particulars of the displacements observed in the chromosphere and prominences are given in the following table :—

TABLE III.—DISPLACEMENTS OF HYDROGEN LINES.

Date.		Time I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1923		H.	M.	°	°		A.	A.	A.	
January	3	9	12		6	E	1			At base.
	4	11	34	2		W	2			At top.
	5	8	45	7		W	Slight			
	6	9	17	4		W		1		At base.
	6	9	19	8		W		1		Do.
	6	9	22	10		W		2		Do.
	6	9	20	12		W	1	0·5		To red at top ; to violet at base.
	7	8	32	84		E		Slight		
	7	8	48		51	W		1·5		At top.
	8	9	4	50		E	1			At base.
	8	8	52		3	W		0·5		Do.
	8	8	44	37		W	1			At top.
	9	10	50	69·5		E	0·5			
	9	10	55	16		E		Slight		
	9	10	58		22	E	0·5			
	17	8	49		40	W	Slight			At top.
	18	8	54		35	E		1		Do.
	19	8	35	45		E	2			
	19	8	37	30		E	2			
	19	8	44	1		E		0·5		
	19	8	27		44·5	W		Slight		
	20	9	17	56		W		0·5		At top.
	20	8	46	75		E		Slight		At base.
	21	9	7	5		E	1			Do.
	21	8	58	56·5		W	1·5			At top.
	22	8	35	82		E	Slight			
	22	8	4	12·5		W	0·5			
	23	8	29	23·5		W		Slight		
	24	9	5	76		E	Slight			At base.
	24	8	54		58 5	E	1			Do.
	28	9	13	11·5		E		0·5		At top.
	29	8	42	49		E		1		Do.
	29	9	14	8		E	Slight			
	30	8	40	54		E	Do.			
	31	9	28		7·5	W	1			At base.
	31	9	12	5		W		1		Do.
February	1	8	47	66·5		E		Slight		
	1	8	44	55		E	1			At top.
	1	8	42	42		E		0·5		At base.
	1	8	50	9		W	1			
	2	8	46	45·5		E	Slight			
	2	8	35	19		W		2		
	3	9	2		37·5	W	1			At top.
	4	8	32	83		E		Slight		
	4	8	30	55		E	0·5			
	5	9	34		34	E	0·5			

Date.		Time I.S.T.		Latitude.		Limb.	Displacement.			Remarks
				North.	South.		Red.	Violet.	Both ways.	
1923.		H.	M.	°	°		A.	A.	A.	
February	5	8	58	64		W	1			At top.
	6	8	28		35·5	W		Slight		
	7	9	19	52·5		W	0·5			At top.
	10	9	24	83·5		E	Slight			
	11	8	55		2	W		Slight		
	11	8	52	77		W	1			At base.
	12	9	4		75·5	E	1			
	13	8	20	73		W			Slight	
	14	9	23		6	W	Slight	0·5		
	15	8	42	68		E		Slight		
	15	9	24		18	E		1		At base.
	16	8	27	63		E	Slight			
	17	8	44	46·5		E	Do.			
	18	9	4	30		E		Slight		At top.
	19	8	48		39·5	W		Do.		
	22	8	58	20		E	1·5	2·5		
	22	8	40	23		W	1			At top.
	23	8	30	35·5		E	0·5			Do.
	23	8	53	14		E	0·5			At base.
	23	9	4		83	W	0·5			
	23	8	44		21	W		0·5		
	25	8	42	69		E	1			
	25	8	46	81		W		1		
	26	8	43	65		E		Slight		
	26	9	2	29		E		0·5		At base.
	26	8	52	15		W		2		Do.
	27	8	39	36·5		E	Slight			
	28	8	47		79·5	E	3			
March	1	8	34	60		E	0·5			
	1	8	40	57		E		0·5		At base.
	1	8	37	49		E	Slight			At top.
	1	8	56	50		E	0·5			
	1	8	50		1·5	W		0·5		
	1	8	44	81·5		W	1			
	2	8	28	72		E		Slight		
	2	8	36		7·9	E		0·5		
	2	8	31	28		W	Slight			At top.
	4	9	4	16		E	2			Do.
	4	9	6		81	E	Slight			
	4	8	52	28		W		Slight		
	4	8	50	30		W	0·5			At top.
	5	8	45	82·5		E		Slight		
	5	8	44	71·5		E	Slight			
	5	8	40	50		E	0·5			At top.
	5	8	52	2		W	1			Do.
	6	8	39		17·5	W	1			Over whole height 30″.
	6	8	45	63		W		Slight		
	7	8	40	57·5		E		Do.		
	7	8	46	53		W	0·5			
	9	8	50	14·5		E	1	1·5		To red at base ; to violet at top.
	9	8	27	82		W		1		At base.
	11	8	39	49		E		0·5		Do.
	12	8	30	50		E		1		At top.
	14	9	28	52		E	1			Do.
	14	9	24	2		W		Slight		
	14	9	14	82·5		W		Do.		
	16	9	7	50		E		2		At top.
	16	9	20		50·5	W		0·5		
	18	9	8	22		E		Slight		At base.
	19	8	32	82		E	Slight			At top.
	19	8	43	69		E	Do.			
	19	8	50		79·5	E	1	2		To red at top to violet at base.
	20	8	32	57·5		W		Slight		
	20	8	32	74·5		W		Do.		
	21	8	58	21·5		W	0·5			At top.
	23	8	30	80		E	Slight			

Date.		Time I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1923		H.	M.	°	°		A.	A.	A.	
March	23	8	28	72·5		E	1			
	23	8	44	48		W	2			At top.
	23	8	40	58·5		W		Slight		
	23	8	34	65		W		0·5		
	24	8	37	34·5		E	Slight			
	24	8	47	59·5		W	Do.			
	25	9	8	39·5		E	Do.			
	25	8	58		8	W	Do.			
	26	8	46	85·5		E	1			At top.
	26	8	44	59		E		0·5		
	26	8	40	17·5		E	Slight			
	27	8	38	9		W	Do.	1		5 A to violet at 8h 50
	27	8	36	52		W	Do.			At top.
	27	8	34	53		W		Slight		
	28	8	47		23	E	Slight			At base.
	28	8	37	7		W		0·5		
	28	8	32	45		W	1			At base.
	29	8	40	70		F.	0·5			At top.
	29	8	37	49		E		Slight		
	29	8	43	83		W	1			At top.
	30	9	9	81		E	Slight			
	30	9	15	56		E	0·5			At base.
	30	9	20		67	E	Slight			
	31	8	40	26		W	1			
April	1	8	44	55·5		W	Slight			
	3	8	2		68·5	E	Do.			
	4	8	26	79·5		E		Slight		
	4	8	41	19		E	Slight			
	5	8	34		75	E	0·5			
	5	8	25		37	W			Slight	
	6	8	43	52·5		W	0·5			At top.
	7	8	20	15		W	0·5			
	8	8	32	25		E		Slight		
	8	8	47		41	W		1		At base.
	9	8	50	69		E	1			At top.
	9	8	44	25		E		Slight		
	9	8	42	17		E		1		At base.
	9	8	55	54		W	1			At top.
	10	9	10	56		W		Slight		
	11	8	40	22		E		1		At base.
	11	9	8		0	E	Slight			
	14	8	26		Axis.	...	Do.			
	15	9	3	9		W	0·5			
	15	9	8	53		W		Slight		At base.
	16	10	36	54		W		Do.		
	21	9	12	11		E		Do.		At base.
	22	8	40	34		E		Do.		
	22	8	47	59		W		Do.		At base.
	26	8	18	57·5		E		Do.		
	26	8	20	53		E	1			At top.
	27	8	31	41		E		0·5		
	27	8	40	42		W		Slight		
	29	8	40	64·5		E		Do.		
	29	8	50		54·5	W		1·5		At top.
	29	8	44		42	W	Slight			
	30	8	54	45		E	Do.			
	30	9	15		59·5	W		0·5		
May	1	8	30	12		E		Slight		
	1	11	20	79		W			Slight	
	2	8	46	85		E		Slight		
	2	8	42	59		E	0·5			
	3	8	55		71	E	Slight			
	3	8	48	59·5		W	Do.			
	4	8	44	42		E		1		At top.
	4	8	48	71·5		W		Slight		

Date.		Time I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1923		H.	M.	°	°		A.	A.	A	
May	6	8	44	57		E	Slight			
	6	8	53	51		E	Do.			At base
	6	8	56	22		E	0·5			
	7	8	31	67		E	1			
	8	8	45	Equator.		E		Slight		At top.
	8	8	40		84	W	Slight			
	8	8	25		41·5	W		Slight		
	8	8	35	68·5		W	Slight			
	9	8	44	80·5		E		Slight		
	9	8	52		85·5	E	1			
	10	8	32		29	W		2		
	10	8	40	78·5		W	2			
	11	9	0		30	W	1			At top.
	13	8	48	60		E		Slight		
	13	8	50	47		W	0 5			
	14	8	48	79·5		E		Slight		
	14	8	53		20	W	0 5			At top.
	16	8	48		15	W		Slight		
	17	8	24		4	W		Do.		
	19	8	30	84·5		W		2		
	20	8	30	52 5		E		0·5		
	20	8	35	67		W		Slight		
	21	8	32	69		E	Slight			
	21	8	35	41·5		E	Do			
	21	8	46	31		W	0·5			At top.
	22	8	32		88	W	1			
	22	8	30		74	W	1			
	23	9	10	17		W		Slight		At base.
	24	8	38	55		E		0 5		Do.
	24	8	35	40		E	0 5			At top.
	24	8	50		9	E		0·5		
	25	8	51		1	W	0 5			
	28	8	48	76		E		1		At base.
	28	8	54	58		W		1		Do.
	29	8	30		68	W	1			
	30	9	8		42	W		Slight		
June	1	8	48	57		E		Slight		
	2	9	2	53		E		0·5		
	2	9	14		18·5	W	1			At top.
	4	11	26	14		W		Slight		
	5	9	28	22		E	1			At base.
	5	8	34		34	E		1		
	6	11	44	46		E		Slight		
	7	9	45		81·5	E		0·5		
	8	8	44	61		E		Slight		
	8	8	48	47·5		W	0 5			
	10	9	2	49		W		0 5		
	11	8	54	9		E		Slight		
	11	8	55		31	E	0·5			
	15	8	54	52		E	0·5			
	16	8	33		13	W		0·5		
	16	8	30	55		W	1			At top.
	18	10	10		25	W	0·5			Do.
	20	8	50	34		W		Slight		At base.
	20	8	36	84		W		0·5		
	27	11	.15	4		W	1			
	29	9	53		6	E	0·5			
	29	9	34	84·5		W	Slight	0·5		To red at top ; to violet at base.

The total number of displacements was 242, of which one was on the equator and the rest were distributed as follows :—

Latitude.		North.	South.
1°—30°		55	25
31°—60°		72	19
61°—90°		52	18
	Total ...	179	62

East limb	127
West limb	114
Pole	1
Total ...	242

126 displacements were towards the red, 113 towards the violet and 3 both ways simultaneously.

Reversals and displacements on the disc.

Twenty-two bright reversals of the Hα line, 7 dark reversals of the D_3 line and 8 displacements of the Hα line on the disc were observed during the half-year. Their distribution is shown below :—

	North.	South.	East.	West.
Bright reversals of Hα	12	10	9	13
Dark reversals of D_3	4	3	2	5
Displacements of Hα	3	5	4	4

Of the displacements, six were towards the red and the rest towards the violet.

Prominences projected on the disc as absorption markings.

Photographs of the Sun's disc in Hα light were available from the co-operating observatories for a total of 174 days counted as 166½ effective days. The mean daily areas of Hα absorption markings (corrected for foreshortening) in millionths of the Sun's visible hemisphere, and the mean daily numbers are given below :—

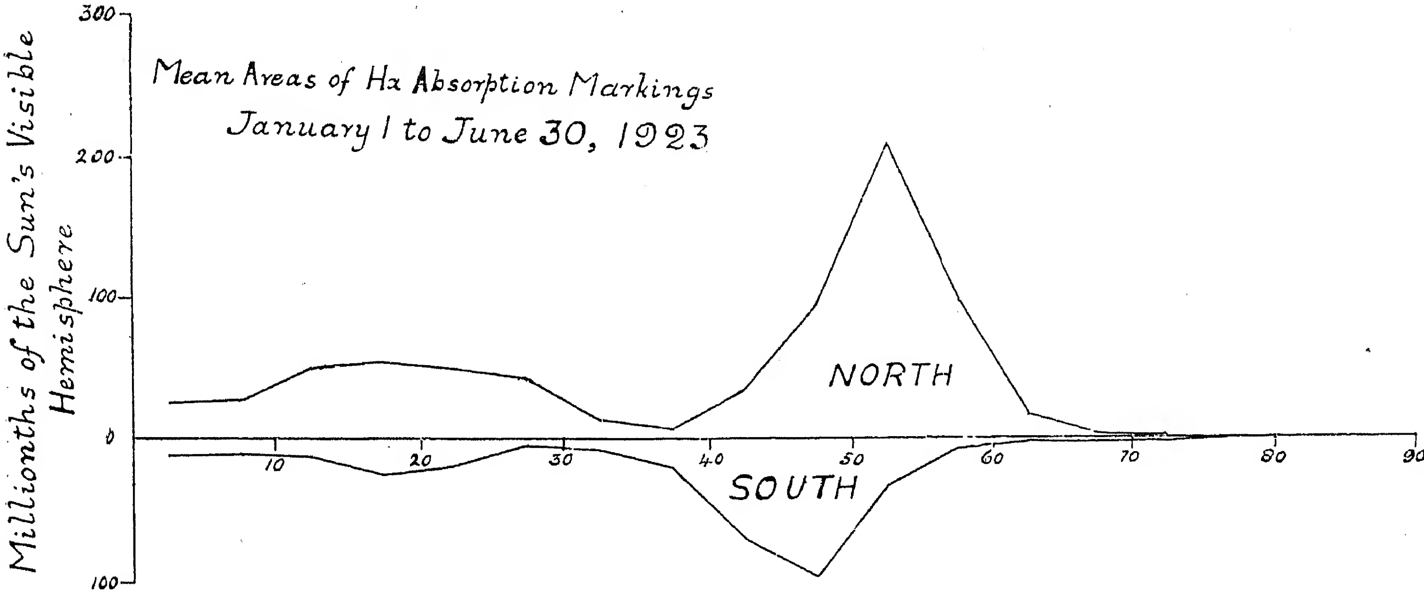
	Mean daily areas.	Mean daily numbers.
North	728	5·2
South	331	3·3
Total ...	1059	8·5

For comparison with previous bulletins issued prior to the co-operation of other observatories, the mean based on Kodaikanal photographs alone are also given, 162 days of observation being counted as 152½ effective days.

	Mean daily areas.	Mean daily numbers.
North (Kodaikanal photographs only)	688	4·8
South Do.	301	3·1
Total ...	989	7·9

These figures indicate an increase of 7 per cent in areas and a decrease of 11 per cent in numbers compared with the previous half-year.

The distribution of mean daily areas in latitude is shown in the following diagram. Compared with the second half-year of 1922 there is greater activity in the belt near 50° and in the southern hemisphere the maximum has advanced 5° towards the pole.



The absorption markings resemble prominences at the limb in their western preponderance, the percentage east being 48·08 for areas and 48·51 for numbers.

The thanks of the Director are due to the staffs of observatories at Mount Wilson, Meudon and Yerkes for the material they have forwarded to Kodaikanal and for the promptness with which they have responded to his requests.

THE OBSERVATORY, KODAIKANAL,
17th March 1924.

T. ROYDS,
Director, Kodaikanal and Madras Observatories.

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Kodaikanal Observatory.

BULLETIN No. LXXV.

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE SECOND HALF OF THE YEAR 1923.

In accordance with a resolution of the International Astronomical Union meeting held in Rome in 1922, the Kodaikanal Observatory has undertaken, with effect from 1st January 1923, the work of compilation and discussion of statistics derived from photographs of prominences and $H\alpha$ absorption markings of the Sun. All observatories taking prominence and $H\alpha$ spectroheliograms of the Sun have been asked to co-operate by supplying copies of their photographs on those days when the Kodaikanal record is imperfect or wanting. In this Bulletin 11 K_3 disc plates and 34 $H\alpha$ disc plates from the Meudon Observatory and 2 prominence plates from the Yerkes Observatory have been used to supplement the records available at Kodaikanal for the second half of the year 1923. The publication of this bulletin has been delayed through waiting for 41 prominence plates and 31 $H\alpha$ plates from the Mount Wilson Observatory, but as it now appears that these have been lost in transit, they could not be included in the discussion. If these photographs turn up eventually, the data for this half-year will be corrected in a later bulletin.

When incomplete or imperfect photographs from more than one observatory are available for the same day, the best photograph is chosen as representing the solar activity of that day after weighting it according to its quality, and the remaining photographs are ignored.

The mean daily areas and numbers of prominences during the half-year are given below. The means are corrected for incomplete or imperfect observations, the total of 142 days being reduced to 112 effective days.

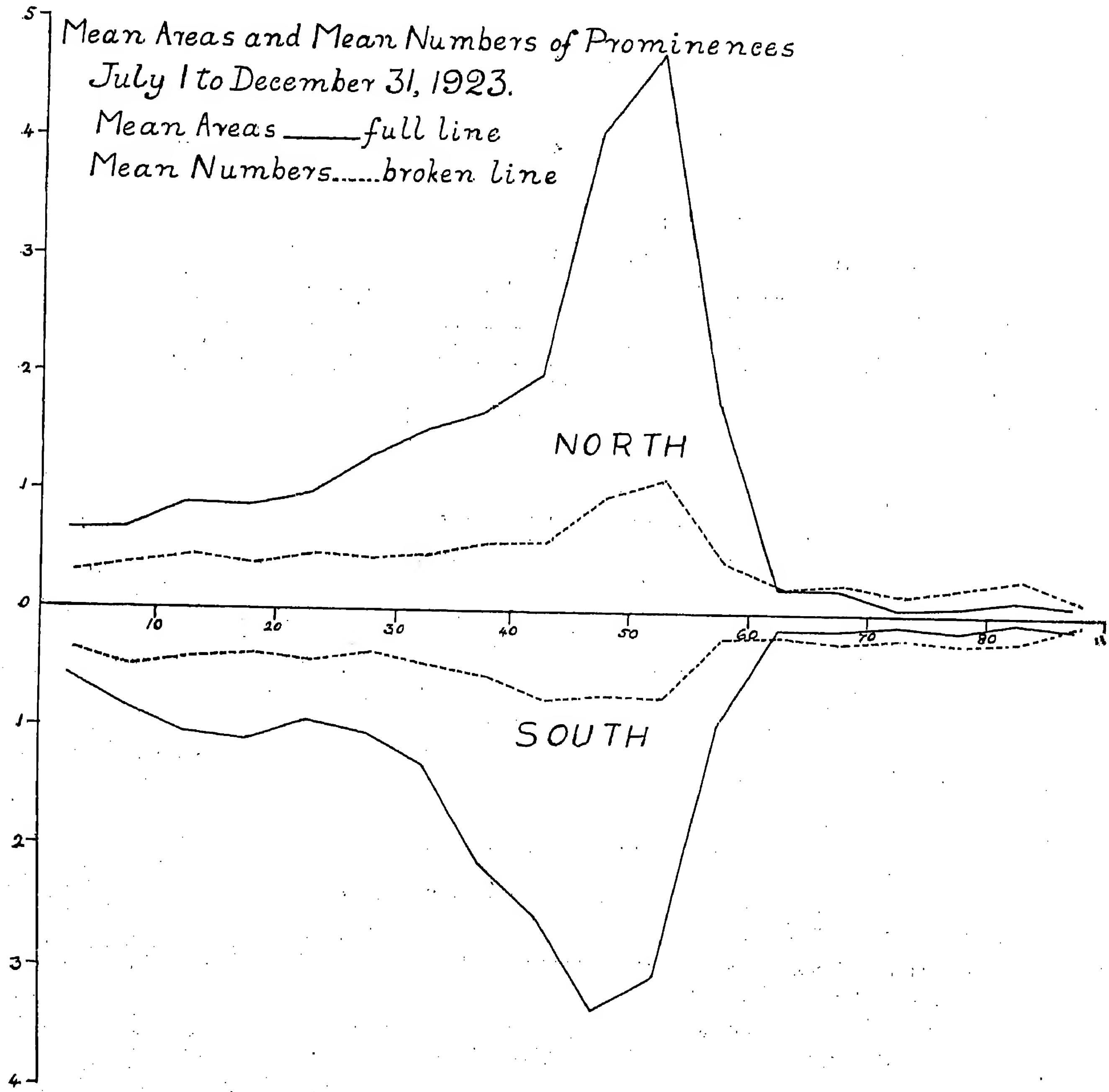
	Mean daily areas (square minutes).	Mean daily numbers.
North	2·20	7·89
South	1·96	7·11
Total ...	4·16	15·00

Compared with the previous half-year, areas show a decrease of 9 per cent and numbers a decrease of 6 per cent in the northern hemisphere. In the southern hemisphere areas have decreased by 5 per cent and numbers remain practically unchanged.

For comparison with previous bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 135 days being counted as 108 effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North (Kodaikanal photographs only)	2 22	7·98
South do.	1·96	7·15
Total ...	4·18	15·13

The distribution of the prominences in latitude is represented in the accompanying diagram, in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude. The ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line. The distribution is similar to that during the first half of 1923, but there is a reduction in activity from the equator to latitude 30° in both hemispheres.



The monthly, quarterly and half-yearly areas and numbers and the mean height and mean extent of the prominences on photographs from the co-operating observatories are given in table I. The unit of area is 1 square minute of arc. The mean height is derived by adding together the greatest heights reached by individual prominences and dividing by the total number of prominences observed; the mean extent is derived by adding together the lengths of the base on the chromosphere of individual prominences and dividing by the total number of prominences.

TABLE I.—ABSTRACT FOR THE SECOND HALF OF 1923.

Months.	Number of days (effective).	Areas.	Numbers.	Daily Means. Areas.	Daily Means. Numbers.	Mean height.	Mean extent.
						″	°
July	14½	60·3	178	4·5	13·0	35·5	3·61
August	18½	63·6	285	3·4	15·4	29·8	3·26
September	20¾	84·8	334	4·1	16·1	31·7	3·42
October	16¾	67·6	251	4·0	15·0	37·0	2·80
November	25	123·9	390	5·0	15·6	35·6	4·08
December	16½	64·5	244	3·9	14·8	34·0	3·51
Third quarter	53¾	208·7	797	3·9	14·9	31·9	3·40
Fourth quarter	58¼	256·0	885	4·4	15·2	35·6	3·56
Second half-year	112	464·7	1682	4·2	15·0	33·8	3·49

Distribution east and west of the Sun's axis.

There is again a western preponderance of both areas and numbers as will be seen from the following table :—

1923 July to December.	East.	West.	Percentage East.
Total number observed	787	896	46·48
Total areas in square minutes	225·1	239·6	48·44

Metallic prominences.

Only two metallic prominences were observed. Both of them were recorded in the month of November and their details are given below :—

TABLE II.—LIST OF METALLIC PROMINENCES OBSERVED AT KODAIKANAL, JULY TO DECEMBER 1923.

Date.		Time I.S.T.		Base.	Latitude. North.	Latitude. South.	Limb.	Height.	Lines
1923		H.	M.	°	°	°		″	
November	4	9	11	11	30·5		East	70	D_1, D_2, 6677.
,,	10	9	58	3	32·5	...	West	40	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.

Displacements of the hydrogen lines.

Particulars of the displacements observed in the chromosphere and prominences are given in the following table :—

TABLE III.—DISPLACEMENTS OF HYDROGEN LINES.

Date.		Time I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1923		H.	M.	°	°		A.	A.	A.	
July	6	8	54	13		E		Slight		At base.
	6	8	57		53	E		Do.		At top.
	6	8	42	24		W	1	0·5		To red at top; to violet at base.
	6	8	36	75·5		W		Slight		
	14	10	23	19		W		Do.		
	16	9	15	23		W		Do.		
	17	8	35		42	E			Slight	
	18	9	12	5·5		E	0·5			At top.
	18	8	48	22·5		W	1			Do.
	27	9	42		63·5	E		0·5		At base.
	27	9	40		69·5	E		Slight		Do.
August	2	9	35	7·5		W	Slight			
	16	8	51	79·5		E	Do.			At base.
	17	8	40	37		W	Do.			
	17	8	42	71		W		Slight		At base.
	19	8	46		26	W		Do.		
	19	8	44		7	W		Do.		
	19	8	41	38		W	0·5			
	20	8	27		63	W		Slight		
	20	8	20	61·5		W		Do.		
	21	8	44		2	W	Slight			
	21	8	40	53·5		W	Do.			
	23	9	5		40·5	W	Do.			
	24	9	15	55·5		E		0·5		
	24	9	1	31·5		W	Slight			At top.
	25	8	50		32	E	Do.			At base.
	28	8	16		23	W		Slight		At top.
	30	8	42		5	E	0·5			Do.
	31	8	44		21·5	E	0·5			Do.
	31	8	48	13		W	Slight			At base.
September	4	9	21	1		W		Slight		
	6	8	52	30·5		W		Do.		
	9	9	55	53·5		E		0·5		At base.
	10	9	15		66	W		0·5		
	10	9	16	24		W		Slight		
	11	9	11		46	E		1·5		At top.
	11	8	57		33·5	W		1		At base.
	12	9	18	83		W		1		At top.
	13	8	40	17		E	Slight			
	13	8	37	6		E	0·5			
	13	8	32		30·5	E	Slight			
	17	8	44	79·5		W	0·5			
	19	9	54	24		W	1			
	21	8	34		15	W		0·5		At base.
	23	8	41	7		W	Slight			At top.
	23	8	40	13		W		0·5		
	24	8	25		19	E			1	
	24	8	35		64	W		0·5		
	25	8	50	38·5		E		Slight		
	25	8	51	35·5		E	1·5			At base.
	25	8	41	25		W		0·5		Do.
	25	8	32	53		W		Slight		
	27	9	7		77	W		0·5		In chromosphere.
	28	8	45		15	E		Slight		At base.
	30	9	4		53	E	1			

Date.		Time I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1923		H.	M.	°	°		A.	A.	A.	
October	4	8	59		80·5	W	2			
	5	9	20		25	E	0·5			At top.
	5	9	12		34	W	1			At top; 2·5 A at 9 h. 15 m
	5	9	22		34	W		0·5		At base.
	5	9	4	27·5		W	1			At top.
	5	8	58	52		W		0·5		At base.
	6	8	30		73	E	Slight			
	6	8	48		22·5	W		Slight		
	7	8	29	66		W		Do.		
	7	8	27	82·5		W	1			At top.
	8	11	37	52		E	0·5			
	9	9	43	9		E		1		At top.
	9	9	30	4		E	1			At top.
	9	9	33	56		W	0·5			
	12	10	34	6		E		1		At top.
	14	10	47	56		E		1		
	15	9	24	65·5		W		0·5		
	22	9	26	53		E	Slight			
	30	8	18		8	W		Slight		
	31	9	25		5	W	1			At top.
	31	9	20	51		W	Slight			
November	4	9	11	31		E	1	0·5		To red at top; to violet at base.
	5	8	52	51		E	0·5			At top.
	6	8	43	59·5		E	Slight			
	8	8	40	39·5		W		1·5		
	9	9	20	62		E		Slight		
	10	9	58	32·5		E	0·5			
	11	9	8	38		E	Slight			
	11	9	5		70·5	W	Do.			
	11	8	57	60		W		0·5		
	12	8	54		37	W		Slight		
	12	8	38	68		W	0·5			
	16	9	4	47		E		Do.		At base.
	16	8	52	31·5		W	1			At top.
	16	8	38	78·5		W		Do.		
	18	8	40	28		W		Do.		
	18	8	34	69		W	Slight			
	19	8	43		40	W		Do.		At base.
	19	8	35	60		W		Do.		Do.
	20	8	35		64·5	W		Do.		
	22	10	3	26		W	0·5			At top.
	26	8	46	87·5		E		0·5		
December	5	8	35	29		W	0·5	Slight		To red at base; to violet at top.
	11	8	25	56		E	Slight			
	11	8	22		40	E			Slight	Symmetrically widened.
	11	8	32	44		W	0·5			
	12	9	00		77	E		Slight		
	12	9	27	82		W		1		At base.
	12	9	28	87		W	1			At top
	18	10	17		70	W	Slight			
	23	9	20	86·5		E	0·5			
	23	9	27		24	W		Slight		
	24	9	6		85·5	W	1			At top.
	25	8	44	53		E	2			At top; not seen at 9 h. 5 m.
	25	9	00		72	W	2			At top.
	25	8	48	82·5		W	1 5			
	25	8	38	86·5		W		Slight		At base.

The total number of displacements was 115, and they were distributed as follows :—

Latitude.		North.	South.
1°—30°	...	25	14
31°—60°	...	30	13
61°—90°	...	19	14
	Total ...	74	41

East limb	43
West limb	72
Total ...	115

Fifty-five displacements were towards the red, 57 towards the violet and 3 both ways simultaneously.

Reversals and displacements on the disc.

Thirty-three bright reversals of the Hα line, 10 dark reversals of the D_3 line and 10 displacements of the Hα line on the disc were observed during the half-year. Their distribution is shown below :—

	North.	South.	East.	West.
Bright reversals of Hα	17	16	19	14
Dark reversals of D_3	5	5	7	3
Displacements of Hα	6	4	6	4

Nine displacements were towards the red and one towards the violet.

Prominences projected on the disc as absorption markings.

Photographs of the Sun's disc in Hα light were available from the co-operating observatories for a total of 141 days counted as 124½ effective days. The mean daily areas of Hα absorption markings (corrected for foreshortening) in millionths of the Sun's visible hemisphere, and the mean daily numbers are given below :—

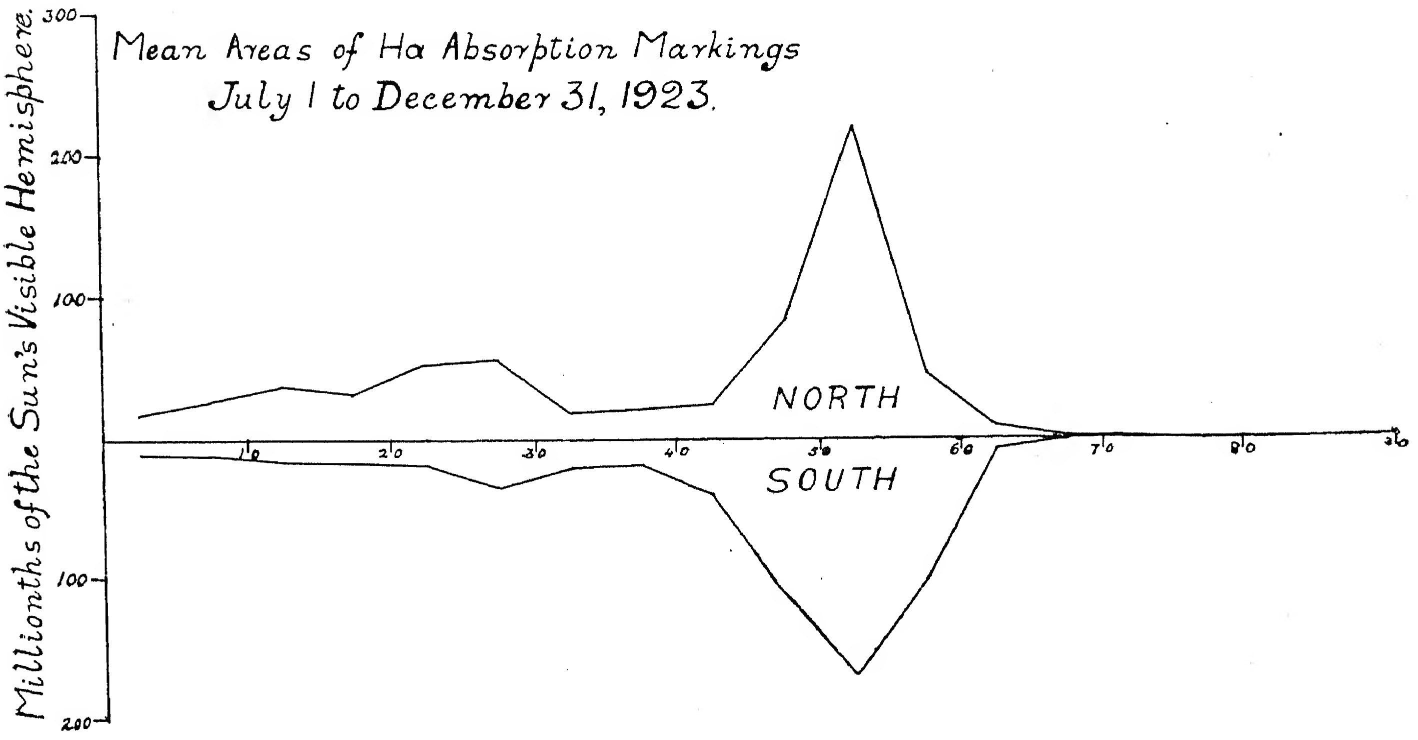
	Mean daily areas.	Mean daily numbers.
North	644	5·4
South	594	4·7
Total ...	1238	10·1

These figures indicate an increase of 17 per cent in total areas and 19 per cent in numbers compared with the previous half-year.

For comparison with previous bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 114 days of observation being reduced to 92 effective days.

	Mean daily areas.	Mean daily numbers.
North (Kodaikanal photographs only)	479	5·1
South do.	621	4·9
Total ...	1100	10·0

The distribution of mean daily areas in latitude is shown in the following diagram and is similar to that for the first half of the year except that the maximum occurs at 50°—55° in both hemispheres and the minimum at 30°—40° is less marked :—



Unlike prominences at the limb, the areas of absorption markings show an eastern preponderance, the percentage east being 53·03. In the case of numbers, however, the eastern percentage is only 48·58.

The Director wishes to thank the co-operating observatories for the photographs they have supplied.

THE OBSERVATORY, KODAIKANAL,
11th November 1924.

T. ROYDS,
Director, Kodaikanal and Madras Observatories.

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Kodaikanal Observatory.

BULLETIN No. LXXVI.

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE FIRST HALF OF THE YEAR 1924.

In pursuance of the programme of work adopted since 1st January 1923 under the auspices of the International Astronomical Union, all observatories taking prominence and $H\alpha$ spectroheliograms of the Sun have been requested to co-operate with the Kodaikanal Observatory by supplying copies of their photographs on those days when the Kodaikanal records are imperfect or wanting. In response to our requirements for the first half of the year 1924, the Mount Wilson Observatory sent prominence plates in calcium K light for 37 days and $H\alpha$ disc plates for 11 days; Meudon Observatory sent K_3 disc plates for 23 days and $H\alpha$ disc plates for 14 days and the Yerkes Observatory sent prominence plates for 3 days. No plates were requisitioned from the Heliophysical Institute at Utrecht as the days on which photographs were available there were represented in the Kodaikanal series.

When incomplete or imperfect photographs from more than one observatory are available for the same day, the best photograph is chosen as representing the solar activity of that day after weighting it according to its quality, and the remaining photographs are ignored.

The mean daily areas and numbers of prominences during the half-year are given below. The means are corrected for incomplete or imperfect observations, the total of 180 days being reduced to 162 effective days.

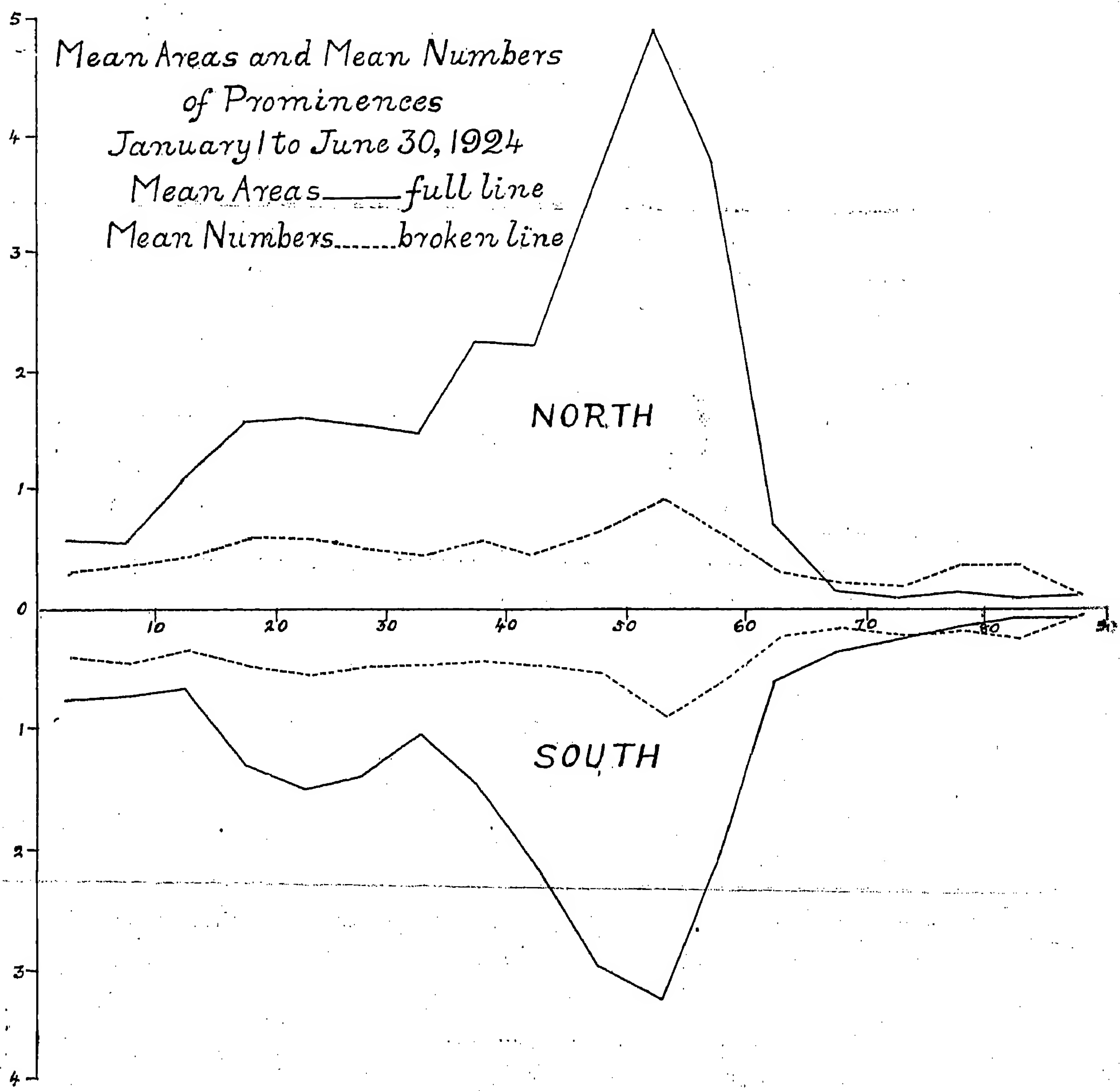
	Mean daily areas (square minutes).	Mean daily numbers.
North	2·62	8·10
South	2·08	7·34
Total ...	4·70	15·44

Compared with the second half of the year 1923, areas show an increase of 19 per cent in the northern hemisphere and 6 per cent in the southern. In the case of numbers, there is an increase of 3 per cent in both the hemispheres.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 170 days of observation being counted as $150\frac{1}{4}$ effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North (Kodaikanal photographs only)	2·71	8·43
South do.	2·16	7·59
Total ...	4·87	16·02

The distribution of the prominences in latitude is represented in the accompanying diagram, in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude. The ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line. The curve shows an increase of activity in the lower latitudes and a slight advance towards the poles, compared with the previous half-year.



The monthly, quarterly and half-yearly areas and numbers, and the mean height and mean extent of the prominences on photographs from all the co-operating observatories are given in table I. The unit of area is 1 square minute of arc. The mean height is derived by adding together the greatest heights reached by

individual prominences and dividing by the total number of prominences observed ; the mean extent is derived by adding together the lengths of the base on the chromosphere of individual prominences and dividing by the total number of prominences.

TABLE I.—ABSTRACT FOR THE FIRST HALF OF 1924.

Months.	Number of days (effective).	Areas.	Numbers.	Daily Means.		Mean height.	Mean extent.
				Areas.	Numbers.		
						"	°
January	27¼	142·4	484	5·2	17·8	32·1	3·76
February	26½	150·0	448	5·7	16·9	38·1	3·85
March	29	128·4	435	4·4	15·0	33·1	3·77
April	28½	133·0	440	4·7	15·4	32·0	3·98
May	27	109·4	382	4·1	14·1	37·4	4·02
June	23¾	98·8	313	4·2	13·1	36·3	4·45
First quarter	82¾	420·8	1367	5·1	16·5	33·6	3·80
Second quarter	79¼	341·2	1135	4·3	14·3	34·9	4·12
First half-year	162	762·0	2502	4·7	15·4	34·2	3·94

Distribution east and west of the Sun's axis.

Both areas and numbers continued to show a western preponderance as will be seen from the following table :—

1924 January to June.	East.	West.	Percentage East.
Total number observed	1187	1315	47·44
Total areas in square minutes	380·6	381·4	49·94

Metallic prominences.

No prominences showing metallic lines were observed during the half-year.

Displacements of the hydrogen lines.

Particulars of the displacements observed in the chromosphere and prominences are given in the following table :—

TABLE II.—DISPLACEMENTS OF HYDROGEN LINES.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1924		H.	M.	°	°		A.	A.	A.	
January	1	9	34	70		E		Slight		
	2	9	38		83·5	E		0·5		
	10	8	59	82		E		Slight		
	10	9	7		4	W	0·5			At base.
	10	9	4	61·5		W	Slight			At top.
	10	9	1	85·5		W		Slight		
	11	8	53	50		W		Do.		
	13	8	40	84·5		E		Do.		
	13	9	4		18	E	0·5			At base.
	13	8	47	28		W		Slight		
	13	8	45	57·5		W	0·5	0·5		To red at top; to violet at base
	14	8	46	52		E		Slight		
	14	9	6		37	E		Do.		
	14	8	57		3	W	Slight			At top.
	14	8	54	56·5		W		0·5		At base.
	14	8	52	64·5		W	0·5			At top.
	14	8	49	83·5		W	1			Do.
	14	8	50	85		W		Slight		At base.
	15	8	44		44	E	Slight			
	16	9	21	85		E		0·5		At top.
	16	9	28	50		W	Slight			Do.
	17	8	58		30	W		0·5		
	17	8	51	50		W		0·5		At base.
	17	8	44	83·5		W		Slight		
	18	8	52	74		E	0·5			
	19	8	58	42		W	Slight			At top
	20	8	34		56·5	E	Do.			At base.
	20	8	32		73·5	E	Do.			
	21	8	43	81·5		E	1			At top.
	21	8	59	48·5		E		1		Do.
	21	9	4	36		E		0·5		Do.
	22	8	54		68·5	E	Slight			
	22	9	6	55·5		W			Slight	More towards violet.
	23	9	12		76·5	E		2		At top.
	23	8	44		5	W	0·5			Do.
	23	8	39	58·5		W	1			Do.
	24	8	55	16		E	0·5			
	24	8	52		15	W	1			At top.
	24	8	48	22		W	0·5			
	24	8	44	57·5		W		Slight		
	25	8	35	47·5		E	Slight			
	26	8	51		50·5	E	1			At top.
	26	9	18	81		W		0·5		At base.
	28	8	54	66·5		E		Slight		
	28	8	58	64·5		W		Do.		
February	1	8	34	76·5		E		Slight		
	1	8	45	64·5		E	1			At top.
	1	8	51		73	W	Slight			Do.
	1	8	37	60·5		W	Do.			
	3	11	28	83·5		E	0·5			At top.
	3	11	24	62		E		Slight		At base.
	4	8	50	77·5		E		Do.		
	4	8	54	55·5		W		1		At base.
	5	9	4		65	W	0·5			At top.
	5	9	2		30	W		Slight		
	5	8	46	67		W	Slight			

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1924		H.	M.	°	°		A.	A.	A.	
February	10	8	41	34·5		E	0·5			At top.
	10	8	48	33		W		0·5		At base.
	11	8	48	16		W		Slight		
	12	9	40	36·5		E	1			
	12	9	51		16	W	0·5			At top.
	12	9	47	69		W		Slight		
	15	9	0		83	E	0·5			
	15	8	50		40·5	W		Slight		
	16	8	30	1		W		Do.		
	17	8	44	79·5		E		Do.		
	17	8	40	54·5		E		0·5		At base.
	18	11	49		34·5	E	0·5			At top
	21	8	40	41·5		E		Slight		
	21	9	1	12		E	0·5			At base.
	21	8	45	57·5		W	0·5			At top.
	22	8	35	23		W		1		
	23	8	44	43·5		W	Slight			At top.
	24	8	52	62		E	0·5			Do.
	25	10	5		55·5	E	Slight			
	25	10	5		57·5	E		0·5		At top.
	26	8	35		75	W	Slight			
	27	9	3		35·5	W	1			At top.
	28	8	52	38·5		E		Slight		
	28	9	20		70·5	W	0·5			At base.
	28	9	6		24	W	1			At top.
	28	8	57	69		W	0·5			Do
	28	8	55	80		W		0·5		At base.
March	3	8	50	82·5		E	1			
	4	9	8	53 5		E	Slight			
	4	9	6		4	E		Slight		
	7	8	50	25		E	0·5			
	7	9	13		64·5	E	Slight			
	7	9	4		54·5	W		0·5		At base.
	7	9	0	25		W	0·5			At top.
	9	8	36	59·5		E	1			Do.
	9	8	58		63	E	Slight			
	10	8	58	80		E	1			
	10	8	50	63		E	1			
	11	8	24	60·5		W		Slight		
	13	8	52	70		E	0·5			At top.
	13	9	9		46·5	E		1		Do.
	13	9	11		82	W		0·5		At base.
	16	8	28		78	W		Slight.		
	17	9	4	59·5		E	Slight			At top.
	18	8	40		24	E	Do.			
	18	8	31	34·5		W	0·5			
	20	9	6		70·5	W	1			At top.
	22	10	52	37		E	0·5			Do.
	22	11	6	71		W		Slight		
	23	8	48	25		E	0·5			
	24	8	38	62		E	1			At top.
	24	8	40	29·5		E	0·5			
	24	8	59		50·5	E		0·5		At top.
	25	8	44	13		E	0·5			
	25	8	40	Equator.		W		Slight		
	27	8	51	58·5		E		Do.		
April	3	8	52	52·5		W		1		At base.
	3	8	49	75 5		W		Slight		Do.
	4	8	34	47·5		W		2		
	5	8	25	60·5		E	Slight			
	5	8	17		82	E	Do.			
	5	8	30		34·5	W		Slight		
	6	8	34	66·5		E	Slight			
	6	8	47		60·5	W		0·5		At base.
	6	8	46		52·5	W		0·5		Do.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1924		H.	M.	°	°		A.	A.	A.	
April	6	8	42	12		W		Slight		
	7	8	43	50·5		W	1			At top.
	8	8	33	70		W		0·5		
	10	8	48	65·5		E	0·5			
	10	8	50	83		W	0·5			
	13	8	45	63·5		E	0·5			At top.
	13	8	28	11		E	0·5			
	13	8	52	81·5		W		Slight		At top.
	15	8	34	60·5		E	Slight			
	15	8	42	69·5		W		Slight		
	20	9	6		44	E	1			At base.
	22	8	51	Equator.		E		Slight		
	24	9	21	42		E	Slight			At base.
	24	9	10		22	W		Slight		Do.
	25	9	24	79		W	1			At top.
	26	9	21	19		W	Slight			Do.
	27	8	38	17		E		0·5		At base.
	27	9	15		54·5	E	0·5			Do.
	27	8	56		32	W	1			At top.
	28	8	42	80		E	Slight			
	28	8	54		28	W		0·5		At base.
	29	8	41		29	W	Slight			At top.
	29	8	32	85		W	0·5			Do.
	30	9	31		79	E	1			At base.
	30	9	19	18		W	Slight			At top.
May	1	9	27		18	E		Slight		Do.
	1	9	26		24	E		0·5		Do.
	2	8	42	61·5		E	0·5			Do.
	2	9	2	51		E	Slight			
	4	9	15	41		E	0·5			
	6	8	27	86·5		E	0·5			At top.
	6	8	23	53		E		0·5		At base.
	6	8	15	4		E		1		At top.
	6	8	34		6	W	0·5			
	8	8	41	21		E		0·5		At base.
	9	8	52	16		E		Slight		Do.
	9	9	20		23	W	Slight			
	11	8	59	15		E		1		At top.
	11	9	7		31	E	0·5			Do.
	13	8	42	18		E		0·5		At base.
	16	9	12	55·5		E	0·5			
	17	10	40		36	E	0·5			At base.
	18	9	46	36		E		0·5		Do.
	19	9	12	39		W	1			At top.
	20	8	30	63		E		Slight		At base.
	20	9	15	20		E	1			At top.
	24	9	30		23	W	1			
	26	11	4		30	W	1			At top.
	26	11	0		13	W	0·5			Do.
	27	8	47	81		E	Slight			Do.
	27	8	50	65·5		W		Slight		Do.
	30	9	10		60	E	1			At base.
	31	10	10		58·5	E	2			Do.
June	6	10	40	30		W	0·5			
	8	9	24	31		E		1		At base.
	9	9	32		36	E	0·5			Do.
	19	9	1	82		E		Slight		Do. ; 0·5 A to Red at 9 h. 23 m.
	19	9	14	26·5		W	0·5			
	22	10	50	78		E		Slight		
	24	8	58	35		W		Do.		
	26	9	9	16		E	Slight			
	29	8	45	86·5		E	Do.			
	29	8	54	70		W		Slight		At base.
	30	8	54	83·5		E	1			At top.
	30	9	5	32		W		Slight		
	30	8	58	56		W		0·5		At base.

The total number of displacements was 188, of which two were on the equator and the rest were distributed as follows :—

Latitude.		North.	South.
1°—30°	...	26	21
31°—60°	...	43	22
61°—90°	...	57	17
	Total ...	126	60

East limb	... ...	101
West limb	... ...	87
	Total ...	188

One hundred and five displacements were towards the red, 82 towards the violet and one both ways simultaneously.

Reversals and displacements on the disc.

Forty-three bright reversals of the Hα line, 25 dark reversals of the D_3 line and 17 displacements of the Hα line were observed during the half-year. Their distribution is given below :—

	North.	South.	East.	West.
Bright reversals of Hα	24	19	19	24
Dark reversals of D_3	11	14	9	16
Displacements of Hα	8	9	8	9

Fourteen displacements were towards the red and the rest towards the violet.

Prominences projected on the disc as absorption markings.

Photographs of the Sun's disc in Hα light were available from all the co-operating observatories for a total of 179 days, which were counted as 173 effective days. The mean daily areas of Hα absorption markings (corrected for foreshortening) in millionths of the Sun's visible hemisphere and the mean daily numbers are given below :—

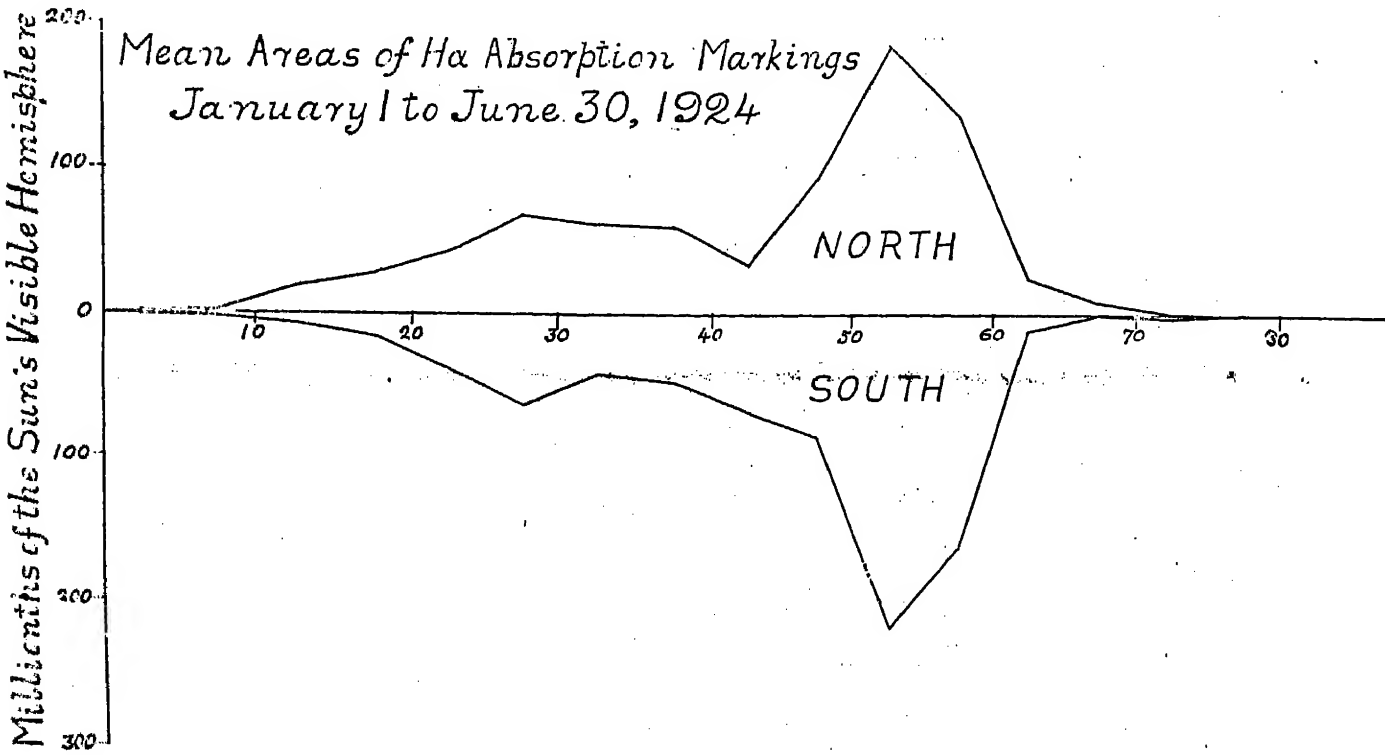
	Mean daily areas.	Mean daily numbers.
North	769	6·0
South	772	5·9
Total ...	1541	11·9

Compared with the previous half-year, areas have increased by 19 per cent in the northern hemisphere and by 30 per cent in the southern. In the case of numbers there is an increase of 11 and 26 per cent respectively in the two hemispheres. The greater percentage of increase in the southern hemisphere has resulted in an equalization of activity in the two hemispheres. This is at variance with prominences at the limb which show during the period under review a distinct northern preponderance.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 161 days of observation being reduced to 155 effective days.

	Mean daily areas.	Mean daily numbers.
North (Kodaikanal photographs only)	756	6·1
South do.	770	5·9
Total ...	1526	12·0

The distribution of the mean daily areas in latitude is shown in the following diagram and is essentially similar to that of prominences at the limb in point of regions of activity.



As in the case of prominences at the limb, the absorption markings show a western preponderance the percentage east being 47·41 for areas and 45·53 for numbers.

Our thanks are due to the co-operating observatories for the photographs supplied by them.

THE OBSERVATORY, KODAIKANAL,
13th March 1925.

A. A. NARAYANA AYYAR,
Assistant in Charge, Kodaikanal Observatory.

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Kodaikanal Observatory.

BULLETIN No. LXXVII.

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE SECOND HALF OF THE YEAR 1924.

In pursuance of the programme of work adopted since 1st January 1923 under the auspices of the International Astronomical Union, all observatories taking spectroheliograms of the Sun have been asked to co-operate with the Kodaikanal Observatory by supplying copies of their photographs on those days when the Kodaikanal records are imperfect or wanting. In response to our requirements for the second half of the year 1924, the Mount Wilson Observatory sent prominence plates for 56 days and Hα disc plates for 42 days; Meudon Observatory sent K_3 disc plates for 35 days and Hα disc plates for 23 days and the Heliophysical Institute at Utrecht sent Hα disc plate for one day. No plates were asked for from the Yerkes Observatory during the half-year.

When incomplete or imperfect photographs from more than one observatory are available for the same day, the best photograph is chosen as representing the solar activity of that day after weighing it according to its quality, and the remaining photographs are ignored.

The mean daily areas and numbers of prominences during the half-year are given below. The means are corrected for incomplete or imperfect observations, the total of 180 days being reduced to 159 effective days.

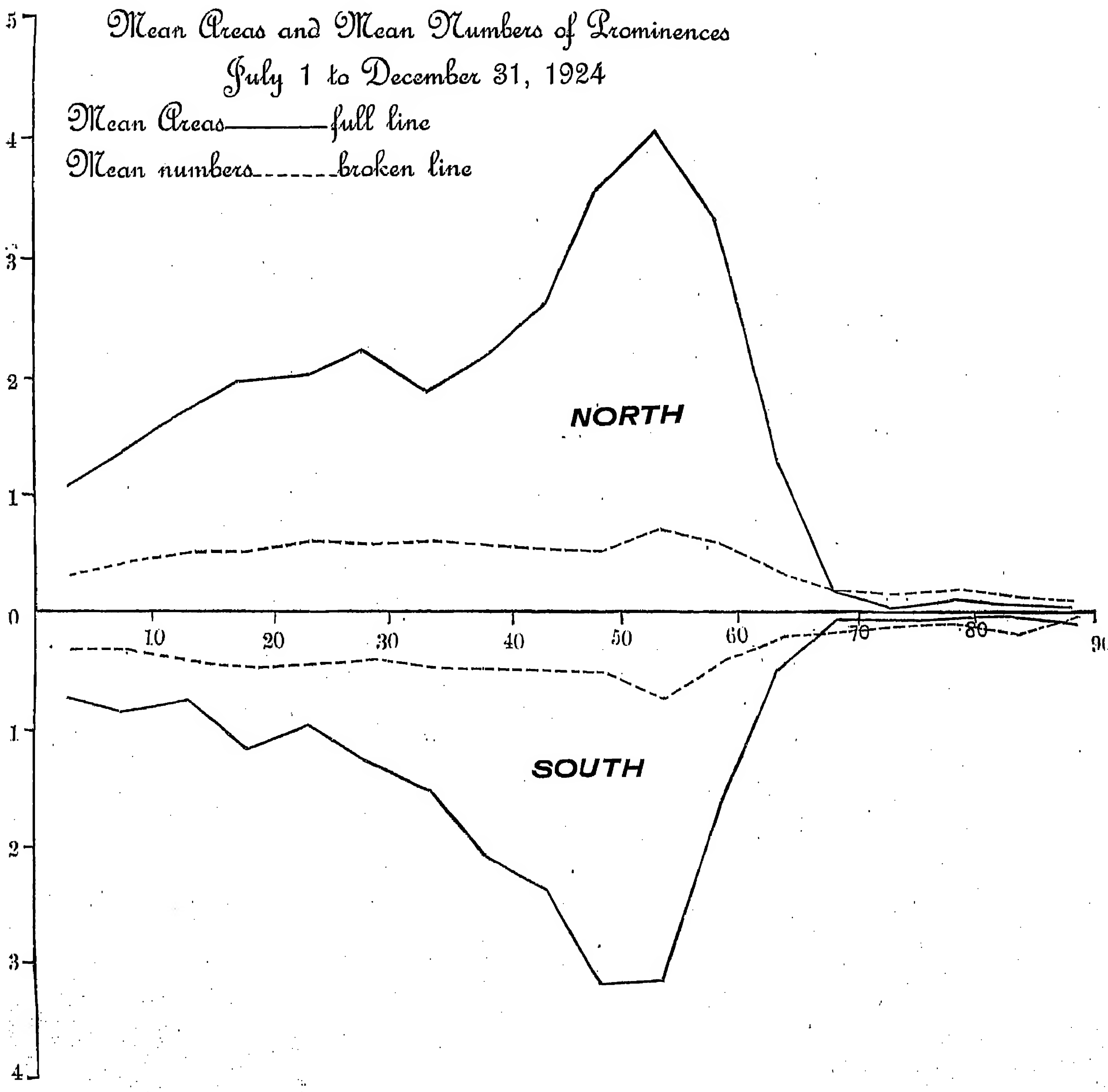
	Mean daily areas (square minutes).	Mean daily numbers.
North	2·97	7·66
South	2·06	6·37
Total ...	5·03	14·03

Compared with the previous half-year, areas have increased by 13 per cent in the northern hemisphere. In the case of numbers, there is a decrease amounting to 5 per cent in the northern hemisphere and 13 per cent in the southern. The activity was more pronounced in the northern hemisphere in the case of both areas and numbers.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 148 days of observation being counted as 125½ effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North (Kodaikanal photographs only)	3·23	8·14
South do.	2·33	6·92
Total ...	5·56	15·06

The distribution of the prominences in latitude is represented in the following diagram, in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude. The ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line. The distribution is practically similar to that during the previous half-year, except for an increase of activity in the northern hemisphere.



The monthly, quarterly and half-yearly areas and numbers and the mean height and mean extent of the prominences on photographs from the co-operating observatories are given in Table 1. The unit of area is 1 square minute of arc. The mean height is derived by adding together the greatest heights reached by individual prominences and dividing by the total number of prominences observed; the mean extent is

derived by adding together the lengths of the base on the chromosphere of individual prominences and dividing by the total number of prominences.

TABLE I.—ABSTRACT FOR THE SECOND HALF OF 1924.

Months.	Number of days (effective).	Areas.	Numbers.	Daily Means.		Mean height.	Mean extent.
				Areas.	Numbers.		
1924						″	°
July	26½	99·6	331	3·8	12·5	36·1	4·22
August	26½	118·7	310	4·5	11·7	37·6	4·14
September	27	111·1	357	4·1	13·2	34·6	4·10
October	26½	170·1	436	6·4	16·5	37·2	5·32
November	26½	159·5	399	6·0	15·0	40·4	4·57
December	26	141·1	393	5·4	15·1	34·4	4·57
Third quarter	80	329·4	998	4·1	12·5	36·0	4·15
Fourth quarter	79	470·7	1228	6·0	15·5	37·3	4·84
Second half-year	159	800·1	2226	5·0	14·0	36·8	4·53

Distribution east and west of the Sun's axis.

There was an excess of prominence areas in the eastern hemisphere and of numbers in the western. The figures are given below :—

1924 July to December.	East.	West.	Percentage East.
Total number observed	1095	1131	49·2
Total areas in square minutes	423·8	376·3	53·0

Metallic prominences.

Details of the metallic prominences observed during the half-year are given in the following table :—

Table II.

TABLE II.—LIST OF METALLIC PROMINENCES OBSERVED AT KODAIKANAL, JULY TO DECEMBER 1924.

Date.		Time I.S.T.		Base.	Latitude.		Limb.	Height.	Lines.
					North.	South.			
1924		H.	M.	°	°	°		"	
July	3	10	50	...	...	30	E	30	D_1, D_2.
September	21	8	47	..	20		W	20	b_1, b_4, b_3, D_1, D_2.
October	3	8	25	5	...	29·5	E	20	5016, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
	4	9	48	1	33·5		E	10	b_1, b_2, b_3, b_4, D_1, D_2.
November	14	8	57	2	29		E	20	b_1, b_2, b_3, b_4, D_1, D_2.
	15	9	52	2	29		E	10	5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
	18	8	55	...	30		E	15	b_1, b_2, b_3, b_4, D_1, D_2, 6677, b_3 being very marked.
	29	8	42	2	27		W	20	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
December	1	8	56	...	24		W	15	4924·1 5016, b_1, b_2, b_3, b_4, 5316·8, 5363·0, D_1, D_2, 6677.
	6	8	55	..	22		E	25	4924·1, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677.
	28	8	42	2	25		W	10	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5316·8, D_1, D_2, 6677, 7065.
	29	9	10	3	25·5		W	10	5016, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, 5363·0, D_1, D_2.

All the metallic prominences were in high latitudes as will be seen from their distribution in latitude given below :—

	11°–20°	21°–30°	31°–40°	Mean latitude.	Extreme latitudes.
North	1	8	1	26°·5	20° and 33°·5
South	...	2	...	29°·8	29°·5 and 30°

Seven were on the east limb and five on the west.

Displacements of the hydrogen lines.

Particulars of the displacements observed in the chromosphere and prominences are given in the following table :—

TABLE III.—DISPLACEMENTS OF HYDROGEN LINES.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1924		H.	M.	°	°		A.	A.	A.	
July	2	8	59		50	E	1			In chromosphere.
	2	9	26		36	W	2			At top.
	3	8	46	33		W		Slight		At base.
	3	8	43	43·5		W		Do.		Do.
	3	8	38	86·5		W	0·5			At top.
	4	10	16	82		E		Slight		
	6	8	56	20		E	1			At base.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North	South		Red.	Violet.	Both ways.	
1924		H.	M.	°	°		A.	A.	A.	
July	6	9	3		78·5	E		Slight		At top.
	6	8	44	84·5		W	1			Do.
	7	8	38	53		W	Slight			Do.
	26	11	21	49·5		E		0·5		Do.
	29	8	41	47		W		Slight		
	29	8	37	70		W		2		
	31	10	32		54	E	1			At top.
August	1	8	51	35		W		Slight		
	3	9	16	5·5		E		1		At top.
	4	11	45	24		W	0·5			Do.
	18	10	50		17·5	W	1	0·5		To red at top ; to violet at base.
	18	10	45	74·5		W		0·5		At base.
	18	10	42	78		W	1			At top.
	19	9	32		14	W	3	1·5		
	25	8	48	70		W		Slight		At base.
	28	10	33	61		E		1		At top.
	29	8	45	30·5		W	2			
	31	10	22	51		W		0·5		At base.
	31	10	20	81		W	0·5			At top.
September	1	9	36	81·5		W		0·5		At base.
	5	11	19		65	W		Slight		Do.
	5	11	12		67	W	0·5			At top.
	6	9	40	21		W	0·5	1		To red at top ; to violet at base.
	7	9	0	62		E	Slight			
	7	9	7	13		E		0·5		At top.
	7	9	14	20		W	1			Do.
	7	8	55	26		W	4			No prominence.
	10	9	7	11		W	0·5			At top.
	11	9	10		28	W	1			Do.
	11	9	0	40		W		Slight		At base.
	12	8	45		42·5	E		Do.		
	16	8	41	49·5		W	Slight			
	21	9	6	71·5		E		Slight		
	21	8	28	67		W	0·5			
	21	8	34	78·5		W	Slight			
	28	8	44		33·5	W	Do.			
October	2	8	50	Axis.		...	1			At top.
	3	8	25		32	E	2			At base.
	3	8	25		27	E		1		At top.
	4	9	40		4·5	E		Slight		
	4	9	30		27·5	E	1	1		To red at base; to violet at top.
	4	9	27		37	E		Slight		At base.
	5	8	48	19		W		Do.		No prominence.
	5	8	46	36		W	1			At top.
	6	9	50	14		W	1			Do.
	10	8	34	79		E		Slight		No prominence.
	10	8	54		74	W	1			At top.
	10	8	52		37·5	W	1			Do.
	12	8	38	64·5		W		0·5		At base.
	14	8	44	36		W	1			At top.
	19	9	2		34	W	Slight			Do.
	20	8	34	8·5		W	Do.			
	23	9	4		64·5	W		Slight		
	23	8	55	63		W	Slight			At top.
	24	9	2	7		W		0·5		
November	7	8	46		40·5	W		Slight		At base.
	10	10	9	67		W	1			At top.
	13	11	50	20		E	1·5			Do.
	14	8	47		62	E	Slight			
	15	9	39	22		E		1		At top.
	15	9	39	20		E		0·5		Do.
	16	8	42	21		E	Slight			
	18	8	55	30		E	6	2		

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1924		H.	M.	°	°		A.	A.	A.	
November	20	9	33	80		W	2			In chromosphere.
	21	9	35		68·5	W		Slight		
	23	9	17	38·5		W	1			At top.
	24	9	8	53		E		0·5		At base.
	24	8	50	51		E	0·5			At top.
	25	9	12		60	E	0·5			Do.
	25	9	1		3	W	Slight			
	25	8	54	63		W		Slight		At base.
	29	8	43	20		W		0·5		
	29	8	42	27		W	1	2		To red at base; to violet at top.
	29	8	38	50		W		0·5		No prominence.
	29	8	35	78·5		W	0·5			At base.
	30	9	20	25		E	1·5			
	30	10	12		59	E		0·5		At top.
	30	10	14		75	W	0·5			At base.
	30	10	18		75	W	4			At top.
	30	9	8	23		W	1			Do.
December	1	8	56	22		W	2			
	1	8	56	20		W		1		At top.
	1	8	47	42		W		Slight		At base.
	2	8	44	29		W	0·5			At top.
	2	8	46	24		W		Slight		At base.
	2	8	34	73		W		Do.		Do.
	3	9	36		78	W	0·5			At top.
	3	9	9	31		W	0·5			
	3	9	9	32		W	1			At top.
	4	8	37	59		E	0·5			Do.
	4	8	45		16	W	1			
	4	8	41	32		W		Slight		At base.
	4	8	39	78		W	0·5			At top
	6	8	55	22		E	2	1·5		
	6	8	49		85·5	E			Slight	
	9	8	33	76		E		Slight		
	9	8	47	25		E		0·5		At base.
	10	9	30	25		E	Slight	0·5		At top.
	10	9	11	38		W		Slight		At base.
	11	8	56	26		E	2			At top.
	13	8	58	6		E	0·5			
	13	8	53		55	W	Slight			
	17	9	38	28·5		E		Slight		At top.
	18	9	5		7·5	W	1			Do.
	18	8	50	38		W	Slight			Do.
	21	8	46	84·5		W		Slight		At base.
	23	8	42	85·5		E		Do.		Do.
	23	9	4	44·5		E	1			At top.
	23	8	55		20	W	1			Do.
	23	8	52	29·5		W	1			Do.
	24	9	9		15	E	0·5			
	24	8	50		5	W		Slight		At base.
	24	8	43	77		W	1			At top.
	25	9	5		19	W		Slight		At base.
	25	9	0	30		W	1			At top.
	25	8	52	65		W	Slight			Do.
	26	9	28		53	E	Do.			Do.
	27	9	10		29	W	1			
	28	8	35	74		E	Slight			
	28	8	25		85·5	W	Do.			
	28	8	38		36	W		1		
	29	9	10	25		W		Slight		At base.
	29	9	10	26·5		W	0·5			At top.
	29	9	10	30		W	1			Do.
	30	8	50		79·5	E		Slight		
	31	9	18		32	E	2			At base.

The total number of displacements was 141, which were distributed as follows :—

Latitude.		North.	South.
1°—30°	... ...	41	17
31°—60°	... ...	24	16
61°—90°	... ...	30	13
	Total ...	95	46

East limb	49
West limb	91
Pole	1
Total ...	141

Eighty displacements were towards the red, 60 towards the violet and one both ways simultaneously.

Reversals and displacements on the disc.

One hundred and fifteen bright reversals of the Hα line, 49 dark reversals of the D_3 line and 34 displacements of the Hα line were observed on the disc during the half-year under report.

Their distribution is given below :—

	North.	South.	East.	West.
Bright reversals of Hα	94	21	61	54
Dark reversals of D_3	43	6	32	17
Displacements of Hα	30	4	18	16

Of the displacements, 23 were towards the red, 8 towards the violet and three both ways simultaneously.

Prominences projected on the disc as absorption markings.

Photographs of the Sun's disc in Hα light were available from all the co-operating observatories for a total of 176 days, which were counted as 167 effective days. The mean daily areas of Hα absorption markings (corrected for foreshortening) in millionths of the Sun's visible hemisphere and the mean daily numbers are given below :—

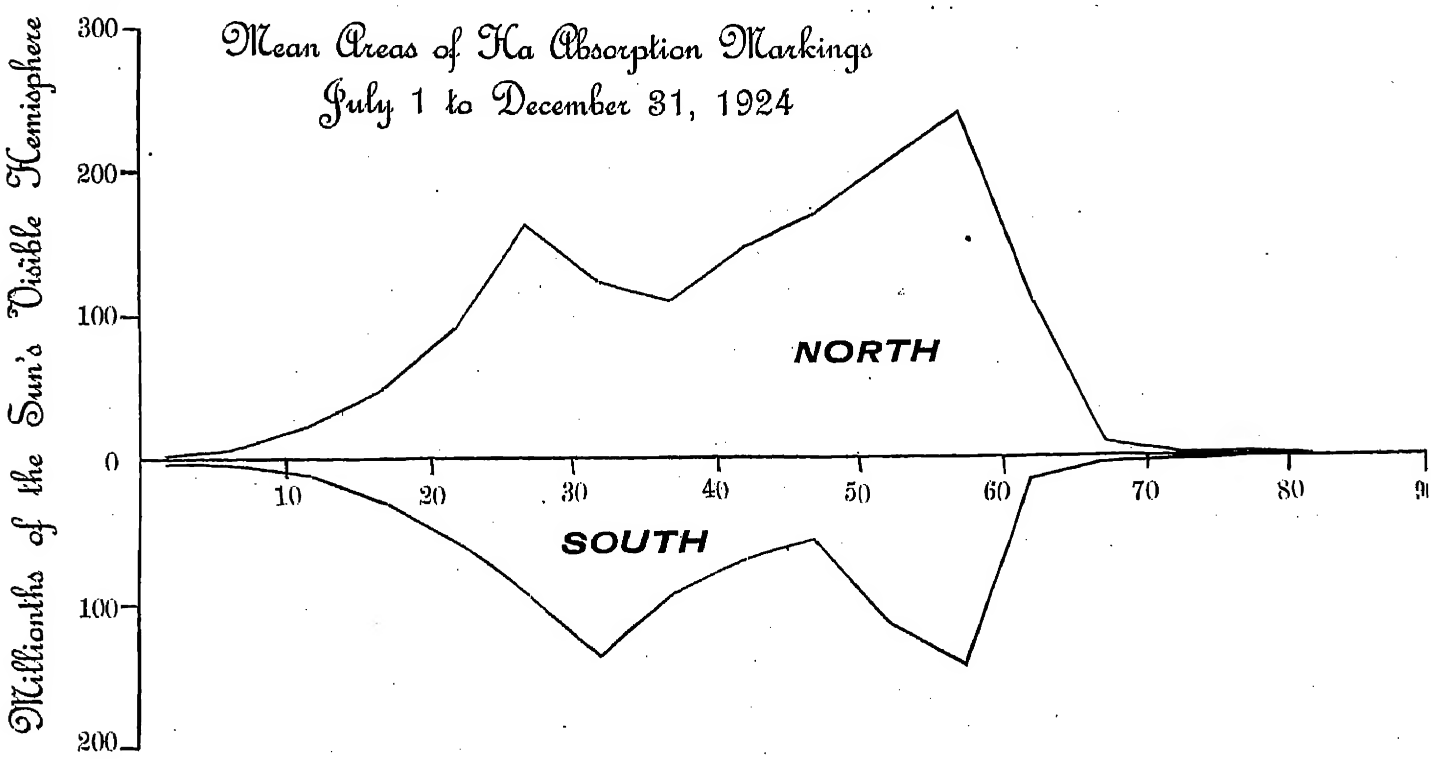
	Mean daily areas.	Mean daily numbers.
North	1470	10·8
South	828	6·1
Total ...	2298	16·9

The above figures indicate a large increase of both areas and numbers in the northern hemisphere compared with the previous half-year. This change has resulted in a preponderance of activity in this hemisphere as in the case of prominences at the limb.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 133 days of observation being counted as 124 effective days.

	Mean daily areas.	Mean daily numbers.
North (Kodaikanal photographs only)	1584	11·7
South do.	908	6·3
Total ...	2492	18·0

The distribution of the mean daily areas in latitude is shown in the following diagram. The curve is markedly different from that of the previous half-year and shows a well defined secondary maximum at latitude 25° to 35° in addition to the primary maximum at 55° to 60° in the two hemispheres.



Both areas and numbers of the absorption markings show an excess in the eastern hemisphere, the percentage east being 51·8 for areas and 50·4 for numbers.

THE OBSERVATORY, KODAIKANAL,
26th September 1925.

A. A. NARAYANA AYYAR,
Assistant in Charge, Kodaikanal Observatory.

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BULLETIN No. LXXVIII.

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE FIRST HALF OF THE YEAR 1925.

In pursuance of the programme of work adopted since 1st January 1923 under the auspices of the International Astronomical Union, all observatories taking spectroheliograms of the Sun have been asked to co-operate with the Kodaikanal Observatory by supplying copies of their photographs on those days when the Kodaikanal records are imperfect or wanting. In response to our requirements for the first half of the year 1925, the Mount Wilson Observatory supplied prominence plates for 17 days and Hα disc plates for 7 days; Meudon Observatory supplied K_3 disc plates for 29 days and Hα disc plates for 15 days and Yerkes Observatory sent prominence plates for 6 days.

When incomplete or imperfect photographs for the same day are available from more than one observatory, the best photograph is chosen as representing the solar activity of that day after weighting it according to its quality, and the remaining photographs are ignored.

The mean daily areas and numbers of prominences during the half-year are given below. The means are corrected for incomplete or imperfect observations, the total of 181 days when plates were available being reduced to 163 effective days.

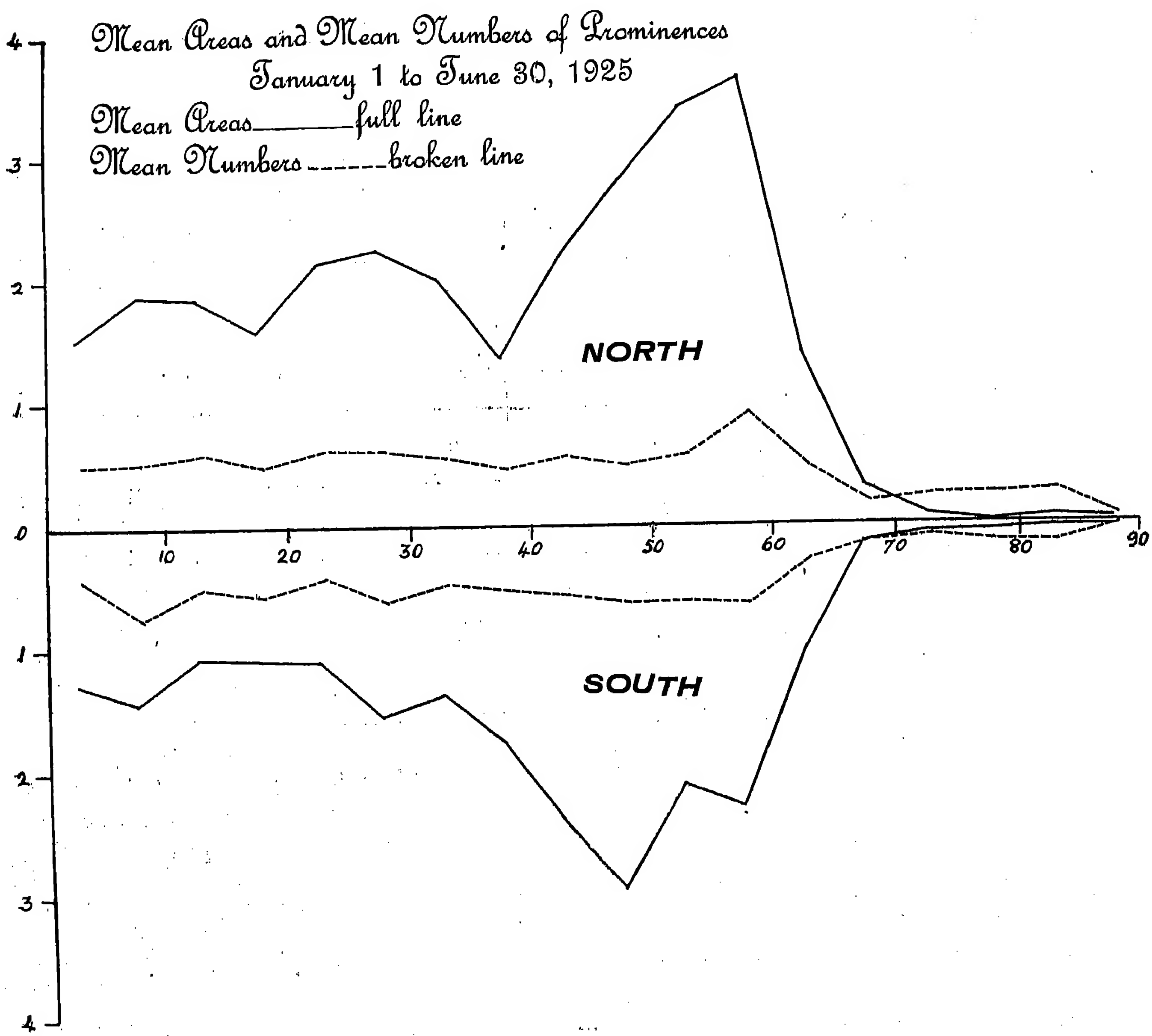
	Mean daily areas (square minutes).	Mean daily numbers.
North	2·86	8·54
South	2·17	7·59
Total ...	5·03	16·13

Compared with the second half of the year 1924, areas show a slight decrease in the northern hemisphere and a slight increase in the southern. In the case of numbers, there is an increase amounting to 11 per cent in the northern hemisphere and 19 per cent in the southern. The activity continued to be more pronounced in the northern hemisphere.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 171 days of observation being counted as 149½ effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North (Kodaikanal photographs only)	2·98	8·90
South do.	2·26	7·92
Total ...	5·24	16·82

The distribution of the prominences in latitude is represented in the following diagram, in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude. The ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line. Compared with the second half of 1924, there has been an increase of activity in equatorial regions, between 30° and 40° and between 60° and 70°, but there has been a decrease between 40° and 50° more marked in the northern than in the southern hemisphere.



The monthly, quarterly and half-yearly areas and numbers, and the mean height and mean extent of the prominences on photographs from all the co-operating observatories are given in Table I. The unit of area is

1 square minute of arc. The mean height is derived by adding together the greatest heights reached by individual prominences and dividing by the total number of prominences observed; the mean extent is derived by adding together the lengths of the base on the chromosphere of individual prominences and dividing by the total number of prominences.

TABLE I.—ABSTRACT FOR THE FIRST HALF OF 1925.

Months.	Number of days (effective).	Areas.	Numbers.	Daily Means.		Mean height.	Mean extent.
				Areas.	Numbers.		
1925						"	°
January	28¾	138·6	449	4·8	15·6	36·0	3·85
February	28	147·2	459	5·3	16·4	37·6	4·02
March	28¾	127·4	455	4·4	15·8	33·8	3·91
April	27¼	128·4	475	4·7	17·4	34·0	3·74
May	27¼	147·3	435	5·4	16·0	35·3	4·51
June	23	130·0	353	5·7	15·3	37·7	4·89
First quarter	85½	413·2	1363	4·8	15·9	35·8	3·99
Second quarter	77½	405·7	1263	5·2	16·3	35·5	4·33
First half-year	163	818·9	2626	5·0	16·1	35·6	4·11

Distribution east and west of the Sun's axis.

Both areas and numbers showed a slight excess in the eastern hemisphere as will be seen from the following table :—

1925 January to June.	East.	West.	Percentage East.
Total number observed	1326	1300	50·5
Total areas in square minutes	411·0	407·9	50·2

Metallic prominences.

Twenty-one metallic prominences were observed during the half-year, of which 16 were north of the equator. Their details are given below :—

TABLE II.—LIST OF METALLIC PROMINENCES OBSERVED AT KODAIKANAL, JANUARY TO JUNE 1925.

Date.		Hour I.S.T.	Base.	Latitude. North.	Latitude. South.	Limb.	Height.	Lines.
1925		H. M.	°	°	°		″	
January	11	9 18	2	28·5		E	10	b_1, b_2, b_3, b_4, D_1, D_2.
	25	8 58		24		W	15	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
February	7	9 2	4	31		E	210	4922·0, 4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5284·2, 5316·8, 5535·1, D_1, D_2, 6677, 7065.
	7	9 20	3		18	E	25	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
	10	9 20	2	35·5		E	20	5016, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	23	9 2	2	31		W	20	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, 5363·0, D_1, D_2.
	24	9 17	3		24	W	30	4924·1, 5018·6, b_1, b_2, b_3 b_4, 5316·8, 5363·0, D_1, D_2.
	24	9 11	1		10·5	W	10	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	24	9 3	2	31		W	15	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5316·8, 5363·0, D_1, D_2.
March	21	8 30	2		31·5	W	30	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	23	8 58			35·5	W	60	4924·1, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677.
	27	9 4	8	26		W	30	4924·1, 5016, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
April	3	9 16		19		W	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
	6	8 45	5	33·5		E	10	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5316·8, 5363·0, D_1, D_2, 6677, 7065.
	6	8 45	3	27·5		E	25	5016, b_1, b_2, b_3, b_4, 5316 8, D_1, D_2, 6677, 7065.
	9	8 58		28		E	15	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	10	9 15	5	22·5		E	65	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5316·8, 5363·0, D_1, D_2, 6677, 7065.
	18	8 55	4	19		E	15	4924·1, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
May	25	9 20		24		W	60	4924·1, 5016, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
June	4	10 35		25		E	20	4924·1, b_1, b_2, b_3, b_4, 5316·8, 5363·0, D_1, D_2, 7065.
	5	9 15		18		W	40	D_1, D_2.

The activity of prominences showing metallic lines was again confined to the higher latitudes as will be seen from their distribution given below :—

	11°—20°	21°—30°	31°—40°	Mean latitude.	Extreme latitudes.
North	3	8	5	26°·2	18° and 35°·5
South	2	1	2	23°·9	10°·5 and 35°

Ten metallic prominences were on the east limb and 11 on the west.

Displacements of the hydrogen lines.

Particulars of the displacements observed in the chromosphere and prominences are given in the following table :—

TABLE III.—DISPLACEMENTS OF HYDROGEN LINES.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1925		H.	M.	°	°		A.	A.	A.	
January	1	11	24	27		E		1		At base.
	2	8	40	55		E		0·5		Do.
	2	8	48	3		W	Slight			At top.
	3	8	52		1	E	1			Do.
	4	9	7	43		W	1			Do.
	5	8	34	58		E		0·5		At base.
	6	8	26	51		W	1			At top.
	10	8	35	71·5		W		Slight		
	15	8	56	84·5		E		1		
	15	9	16		26	E	1	0·5		To red at base; to violet at top
	15	9	8		53	W		1		At base.
	16	11	3	82·5		E	Slight			
	17	8	56	23		W		1		
	18	9	34	79		E		1		At top.
	18	9	21	75·5		E	3			
	19	10	20	61·5		E	0·5			At top.
	19	10	24	53·5		W		0·5		At base.
	20	8	38	77		E		Slight		
	20	8	50	41		W		Do.		
	20	8	41	80·5		W	0·5			
	22	9	4		10	E	Slight			
	22	8	55		29	W		Slight		
	22	8	50	14		W	4	1·5		To red at top; to violet at base.
	23	8	32	48·5		E	0·5			
	23	8	45	21		W	1			
	23	8	41	39		W	0·5			
	23	8	36	76		W		0·5		
	25	8	48	83		E		Slight		
	25	8	58	24		W	1	0·5		
	25	8	51	64·5		W	Slight			
	26	9	4	26		E	Do.			
	26	9	16		20	E		1		At top.
	26	8	59	23		W	0·5			Do.
	26	8	49	60·5		W		0·5		
	27	8	36	75		E		0·5		
	27	8	46	23		W	1			
	27	8	39	75		W		Slight		
	28	9	28		34	E	2			At top.
	28	9	5	41		W	0·5			Do.
	29	8	58		56·5	E	Slight			
	29	8	34	79		W	0·5			
	30	8	37	62·5		E		Slight		
	30	9	9		62	E	0·5			At top.
	30	8	46		16	W		Slight		
	30	8	41	54·5		W		0·5		
February	2	9	28		83·5	E	Slight			
	2	9	8	12		W	0·5			
	3	8	46	79		E		Slight		
	3	9	14	25		E	0·5			At base.
	3	9	17		21	E		Slight		
	3	9	6		79	W		Do.		
	3	9	2		20	W	1			
	3	8	57	32		W	0·5			
	5	8	55	66		E		0·5		
	5	9	24	57·5		E	0·5			
	5	8	53	46·5		E	0·5			
	5	9	31	23		E		1		At top.
	5	9	18	3		W	0·5			

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1925		H.	M.	°	°		A.	A.	A.	
February	6	8	48	64		E	Slight			
	6	9	8	30		E		0·5		At base.
	6	9	14	20		E	1			
	6	9	14	15		E	1·5			
	6	9	20		21	E	1			
	6	9	23		36	E	1			At base.
	6	8	58	43·5		W	1			
	7	9	2	31		E		2		
	7	9	20		18	E	3			At top.
	7	8	45		20	W		Slight		
	8	8	39	73·5		E		Do.		
	8	8	36	61		E	1			
	8	8	34	35		E	1			At base.
	8	8	34	30		E		1		At top.
	8	9	22		16	E		0·5		
	8	9	3	17		W		Slight		
	8	8	51	28		W	1			At top.
	9	11	0	14		E	Slight			At base.
	10	9	20	36		E	3			At top.
	10	9	20	33		E	2			
	10	9	25		11	E		1		
	12	9	58	74·5		E	0·5			
	12	10	38	34		E	Slight			
	12	10	42	11		E		0·5		
	12	10	26	52·5		W	1			
	13	9	12	46		E	0·5			At top.
	13	9	15	34		E	1			Do.
	13	8	54	68		W		Slight		
	14	9	10		55	W		Do.		
	15	8	53	62		E		1		
	15	9	1	41		W	1			At top.
	16	9	12	42·5		E	Slight			
	16	9	17		14	E		0·5		
	16	9	22		80	E		0·5		
	16	9	4		61	W		Slight		At base.
	16	8	55	75·5		W	0·5			At top.
	17	8	58	81·5		E		Slight		
	17	9	18	20		E	1			
	18	9	4	81·5		E		1		
	18	9	29		59	W		1		At top.
	18	9	12	26		W		Slight		Do.
	19	8	41	58		E	1			Do.
	19	8	38	23		E		Slight		
	20	8	44	18·5		E		0·5		
	20	9	17		32·5	E	0·5			
	21	8	42	13		E	Slight			
	21	8	47		41·5	E	Do.			
	22	9	20	22		E	1			
	22	9	8	14		W	Slight			At top.
	22	9	3	31·5		W	0·5			Do.
	22	8	55	76		W	0·5			
	23	8	43	74·5		E	Slight			
	23	8	58	29		W		Slight		
	23	8	48	64		W		Do.		
	23	8	46	75·5		W	1			
	24	8	50	74·5		E	0·5			
	24	9	17		25·5	W	3			At base.
	24	9	17		25·5	W	1			At top.
	26	10	13	62		E	Slight			
	27	8	42	34·5		E	Do.			
	27	9	11	18		E		0·5		At top.
	28	8	34	54		E		Slight		
	28	8	42	37·5		W			Slight	
	28	8	39	58		W		Slight		
	28	8	38	77·5		W		Do.		

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1925		H.	M.	°	°		A.	A.	A.	
March	1	8	50	42		E		1		At base.
	3	8	46	61		E	1			At top.
	3	9	33	22		E	1	1		To red at base; to violet at top.
	3	8	57	80		W	3			
	4	9	25		33·5	E		0·5		
	5	8	53	75		E	1	1		To red at top; to violet at base.
	5	8	48	38·5		E		Slight		
	6	8	54	67·5		E	0·5			
	6	9	14		73·5	E	0·5			
	6	9	1	47		W		1		
	7	9	10		51·5	W		Slight		
	8	9	15	43·5		E		Do.		
	8	9	32		53·5	W	0·5			
	8	9	27		11	W	Slight			
	9	8	46	58·5		E		0·5		
	9	8	0	42		E		0·5		At base.
	9	8	59		31·5	E	Slight			
	9	8	50	69		W	Do.			
	10	8	56	28		E	1			
	10	8	40	28		E		2		
	14	9	5		15	E	Slight			
	16	9	53	47		E	0·5			At base.
	17	8	48	81·5		E		Slight		
	19	10	43		78	E		1		
	21	8	30		33	W		2		At base.
	22	8	22	71·5		W		Slight		
	22	8	21	76		W	Slight			
	22	8	42	36		E		0·5		At base.
	22	9	0		82	E		Slight		
	22	8	55		36	W	1			At top.
	22	8	50	20		W	0·5			
	23	8	44	71·5		E		0·5		
	23	9	18		83	W	0·5			
	23	9	16		71·5	W		1		
	23	9	12		31·5	W	2	1		
	23	8	52	16		W		Slight		At base.
	23	8	50	60		W		0·5		Do.
	24	8	58	82·5		E	0·5			
	24	9	6	60		W		Slight		At top.
	24	9	2	78·5		W		Do.		
	25	9	8	49		E		0·5		At top.
	25	9	2	32		W		0·5		At base.
	26	8	58	63		E	0·5			
	26	9	9		69	W	0·5			
	27	9	14	22		W	1·5	1		To red at top; to violet at base.
	28	8	42	80		E			Slight	
	28	8	43	82		W		Slight		
	29	8	36	42		E	1			At top.
	29	8	54		22	W		Slight		At base.
	29	8	40	80		W	0·5			At top.
	30	8	45	52		E		Slight		At base.
	30	8	53	61		W		Do		
	31	8	52	82		E		Do.		
April	1	10	7		48·5	E		1		
	1	10	7		50·5	E	1			
	2	8	52	70		E		Slight		
	2	8	50	56		E	1			At top.
	2	8	46	39·5		E		0·5		
	2	9	2		33	W		Slight		At base.
	3	9	7	68		E	1			
	3	9	5	58·5		E	0·5			
	3	9	36	16		E	0·5			At base.
	3	9	10	51·5		W		Slight		
	4	8	30	63		E		Do.		
	4	8	53		15	E	1·5			
	4	8	58		59·5	E	Slight			

Date.		Hour I.S.T.	Latitude.		Limb.	Displacement.			Remarks.
			North.	South		Red.	Violet.	Both ways.	
1925		H. M.	°	°		A.	A.	A.	
April	4	8 43	18		W			2	
	4	8 40	49		W			Slight	
	4	8 35	83		W		Slight		
	5	9 19	29		E		0·5		At top.
	5	9 3		83	W		Slight		
	6	8 55	78·5		E	Slight			
	6	8 45	32		E		2		At base.
	6	9 10	23		E		0·5		Do.
	6	9 22		83·5	E		1		
	7	9 12	28		E	1·5			At top.
	7	9 2		27	E		0·5		
	7	9 4	20		W		2		At base.
	7	9 7	20		W	2			At top.
	7	8 57	39·5		W	0·5			
	8	10 39	31		E	1	1		At top.
	8	10 52		83	E		Slight		
	9	8 44	75·5		E	1			
	9	8 42	39·5		E	0·5			
	9	8 58	25		E	1			At top.
	10	9 15	24		E	1			Do.
	10	9 15	20		E		1		At base.
	10	9 20		20	E	0·5			
	11	9 4	44·5		W	0·5			
	12	9 43		3·5	E		1		At top.
	12	9 49		83	E	0·5	0·5		To red at base; to violet at top.
	12	9 53		61·5	W	0·5	1		Do.
	12	9 12	27		W		1		
	12	9 12	28		W	1			
	15	9 27	34		E	1			
	15	9 19	20		E		1		
	15	9 19	19		E	0·5			
	16	9 25	27		E	0·5			At top.
	16	9 50	24		E		1		At base.
	16	9 55		24	E		0·5		
	16	9 38	26		W	1			
	17	8 53	78·5		E	Slight			
	17	9 12		23	E		1		At top.
	18	8 40	73		E		Slight		
	18	8 55	14		E		Do.		
	18	8 46	24		W		Do.		At base.
	20	9 5	47·5		E	1			
	20	9 6	40		E	Slight			
	20	9 1		59·5	W	0·5			
	20	8 55		8	W	2	1		To red at top; to violet at base.
	21	8 46	83		E		0·5		
	21	9 8		6	E		0·5		
	21	9 1		53·5	W		Slight		
	21	8 57		37	W	0·5			
	21	8 51	67·5		W	1			
	22	10 32		9	W		Slight		
	23	9 48	47		E	0·5			
	23	9 42		76	W		Slight		At base.
	24	10 14	80·5		E		0·5		
	24	10 9	53		E	0·5			At top.
	24	10 18	45		W		Slight		
	25	8 42	45		W		Do.		
	27	8 50	69·5		E		Do.		
	28	9 30	83		E	0·5			
	28	9 26	42		E	Slight			
	28	9 44		81	E	Do.			
	30	8 54	15		E	4			At top. 1·5 A to violet at top at $9^h 16^m$.
	30	9 7	29		W		Slight		At base.
May	1	9 45	79		E		Do.		
	1	9 44	66·5		E		1		
	1	9 49	27		W		Slight		

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1925		H.	M.	°	°		A.	A.	A.	
May	2	8	52	12		W		Slight		
	4	9	40	24		E	Slight			
	4	9	42		25	E	1			At base.
	4	9	38		85·5	E		0·5		
	4	9	36		8	W	1			
	5	9	13	36		E	Slight			
	7	9	9	85·5		E	Do.			
	7	9	20		21	E	1			
	8	8	48	75·5		W	0·5			
	9	9	14	22		E	Slight			
	11	8	46	79·5		E	0·5			
	11	8	58	58		E	Slight			At base.
	12	9	3	24		E	6			Do.
	12	8	51	19		E	1·5			At top.
	12	8	58		8	W		Slight		
	12	8	55	60		W	Slight			
	18	11	5	85·5		E	Do.			
	18	11	10		24	E		1		
	19	9	8		38	E	0·5			At base.
	19	9	12		81·5	E	0·5			
	19	8	55	84·5		W	1			
	20	10	15	19		E		1		
	21	9	14	84·5		E	1			
	21	9	12	60		E		Slight		
	21	9	10	46		E	0·5			
	22	9	10		11	E	0·5			At base.
	22	9	13		68	E		Slight		
	22	9	6		22	W	0·5			At top.
	22	9	3	14		W	1			Do.
	24	9	13	15		W	1			At base.
	24	9	11	24		W		1·5		Do.
	24	9	9	47		W		Slight		
	25	9	16	72		E	0·5			
	25	9	12	42		E	0·5			
	25	9	20	24		W	1			At top.
	26	9	39		22	W	Slight			
	27	8	48	28		W	2	1		To red at top ; to violet at base.
	28	8	37	49		W		Slight		
	29	9	35		26	E	0·5			
	29	9	29	22		W	0·5			At base.
	29	9	22	28		W	1			At top.
	30	9	26	23		W	1·5			Do.
	30	9	24	70		W	Slight			
June	1	9	15	5		W	1			At top.
	3	8	58	57		E	Slight			
	3	8	40	73		W	1·5			
	4	10	35	25		E	1	0·5		To red at top ; to violet at base.
	4	10	20		21	W	1			At top.
	5	8	51	81		E	0·5			
	5	8	50	72		E	1			
	5	9	15		18	W		2		At base.
	6	9	30		2	W	Slight			
	8	9	15	80		E		0·5		
	8	9	12		62	W		Slight		
	8	9	0	61·5		W	1	1		To red at top ; to violet at base.
	8	8	55	89		W	0·5			
	9	9	3	83		E		Slight		
	9	8	48	32		E		1·5		At base ; 3 A at 9h 20m.
	9	8	49	24		E	2			At top.
	9	9	20		57	E		2		Do.
	10	10	35	35		W	0·5			
	11	9	6	62		E	2			At base.
	11	8	57	10		W	0·5			
	11	8	46	59		W	Slight			
	12	9	10	84		E	Do.			

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South		Red.	Violet.	Both ways.	
1925		H.	M.	°	°		A.	A.	A.	
June	12	9	20	19		E		0·5		
	12	9	16		14	W	0·5			
	13	8	30	38		E		2		At top.
	14	8	47		40	E	Slight			
	15	9	25		33	W	1	0·5		To red at top; to violet at base.
	16	9	50		25	W		0·5		
	19	9	36	18·5		W		0·5		At base.
	21	9	50	58		E		Slight		
	21	10	2		31	W		0·5		
	21	9	58	37		W	1			
	21	9	56	88		W		Slight		

There was a large increase in the number of displacements, the total number observed being 344 as against 141 in the previous half-year. They were distributed as follows :—

Latitude.		North.	South.
1°—30°	... ...	83	44
31°—60°	... ...	78	29
61°—90°	... ...	86	24
	Total ...	247	97

East limb	195
West limb	149
Total ...	344

One hundred and eighty-three displacements were towards the red, 156 towards the violet and 5 both ways simultaneously.

Reversals and displacements on the disc.

One hundred and sixty-four bright reversals of the Hα line, 73 dark reversals of the D_3 line and 45 displacements of the Hα line were observed on the disc during the half-year. Their distribution is shown below :—

	North.	South.	East.	West.
Bright reversals of Hα	117	47	71	93
Dark reversals of D_3	54	19	27	46
Displacements of Hα	32	13	24	21

Thirty-eight displacements were towards the red, six towards the violet and one both ways simultaneously.

Prominences projected on the disc as absorption markings.

Photographs of the Sun's disc in Hα light were available from Kodaikanal and the co-operating observatories for a total of 175 days, which were counted as 171 effective days. The mean daily areas of Hα

absorption markings (corrected for foreshortening) in millionths of the Sun's visible hemisphere and the mean daily numbers are given below :—

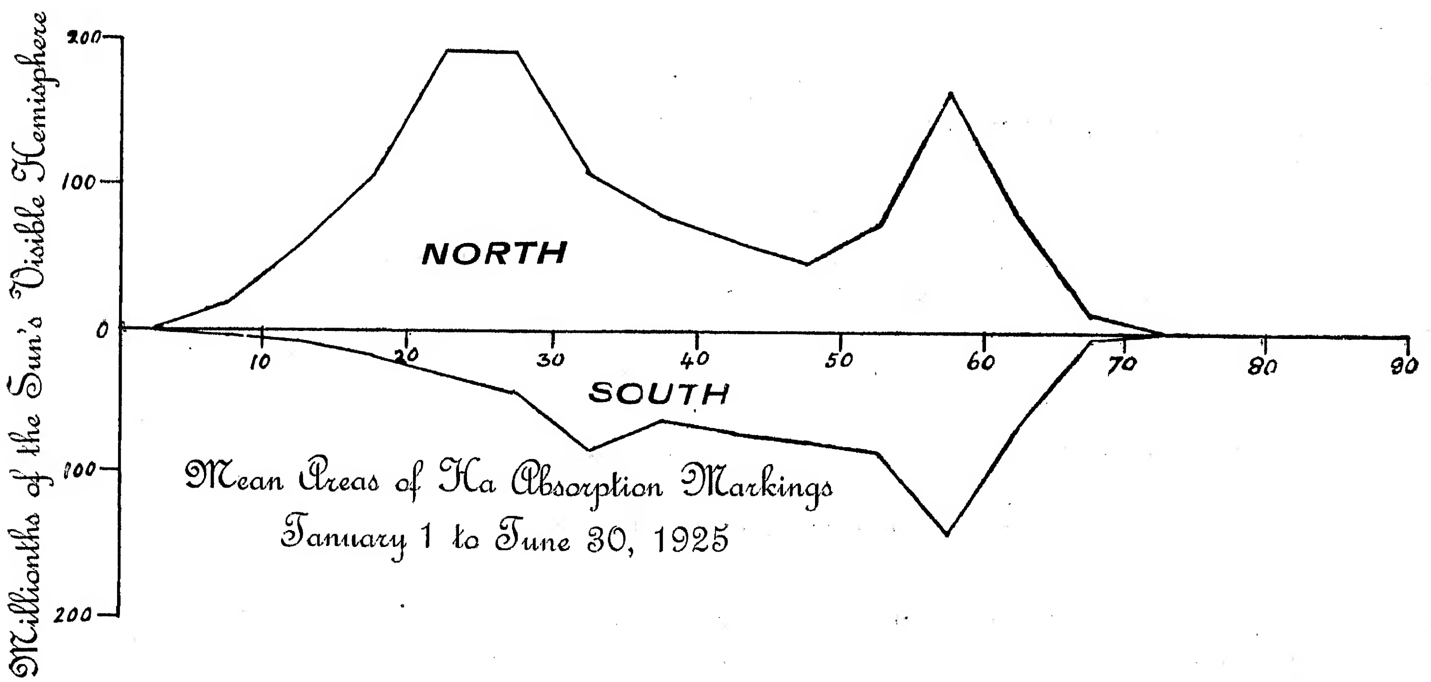
	Mean daily areas.	Mean daily numbers.
North	1203	9·4
South	703	5·5
Total ...	1906	14·9

Both areas and numbers have decreased compared with the previous half-year. As in the case of prominences at the limb, the activity continued to be more pronounced in the northern hemisphere.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 164 days of observation being counted as 158 effective days.

	Mean daily areas.	Mean daily numbers.
North (Kodaikanal photographs only)	1182	9·4
South do.	712	5·5
Total ...	1894	14·9

The distribution of the mean daily areas in latitude is shown in the following diagram and is strikingly different from that of prominences at the limb. In the northern hemisphere the zone of greatest activity is at 20°—30° with a secondary maximum at 55°—60°, whilst in the southern hemisphere, the maximum is at 55°—60° with only slight activity in the other regions.



Mean Areas of Hα Absorption Markings
January 1 to June 30, 1925

As in the case of prominences at the limb, there is an excess of activity in the eastern hemisphere the percentage east being 53·94 for areas and 50·37 for numbers.

Thanks are due to the co-operating observatories for the photographs supplied by them.

THE OBSERVATORY, KODAIKANAL,
19th February 1926.

T. ROYDS,
Director, Kodaikanal and Madras Observatories.

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Kodaikanal Observatory.

BULLETIN No. LXXIX.

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE SECOND HALF OF THE YEAR 1925.

In pursuance of the programme of work adopted since 1st January 1923 under the auspices of the International Astronomical Union, all observatories taking spectroheliograms of the Sun have been asked to co-operate with the Kodaikanal Observatory by supplying copies of their photographs on those days when the Kodaikanal records are imperfect or wanting. In response to our requirements for the second half of the year 1925, Mount Wilson Observatory supplied prominence plates for 40 days and Hα disc plates for 38 days; Meudon Observatory supplied K_3 disc plates for 34 days and Hα disc plates for 31 days and Yerkes Observatory sent prominence plates for 7 days. Eight prominence plates and 7 Hα disc plates taken by Mr. Evershed at his observatory at Ewhurst, Surrey, England during the last three months of the year were also received.

When only incomplete or imperfect photographs for any day are available from more than one observatory, the best photograph is chosen as representing the solar activity of that day after weighting it according to its quality, and the remaining photographs are ignored.

The mean daily areas and numbers of prominences during the half-year are given below. The means are corrected for incomplete or imperfect observations, the total of 181 days when plates were available being reduced to 151 effective days.

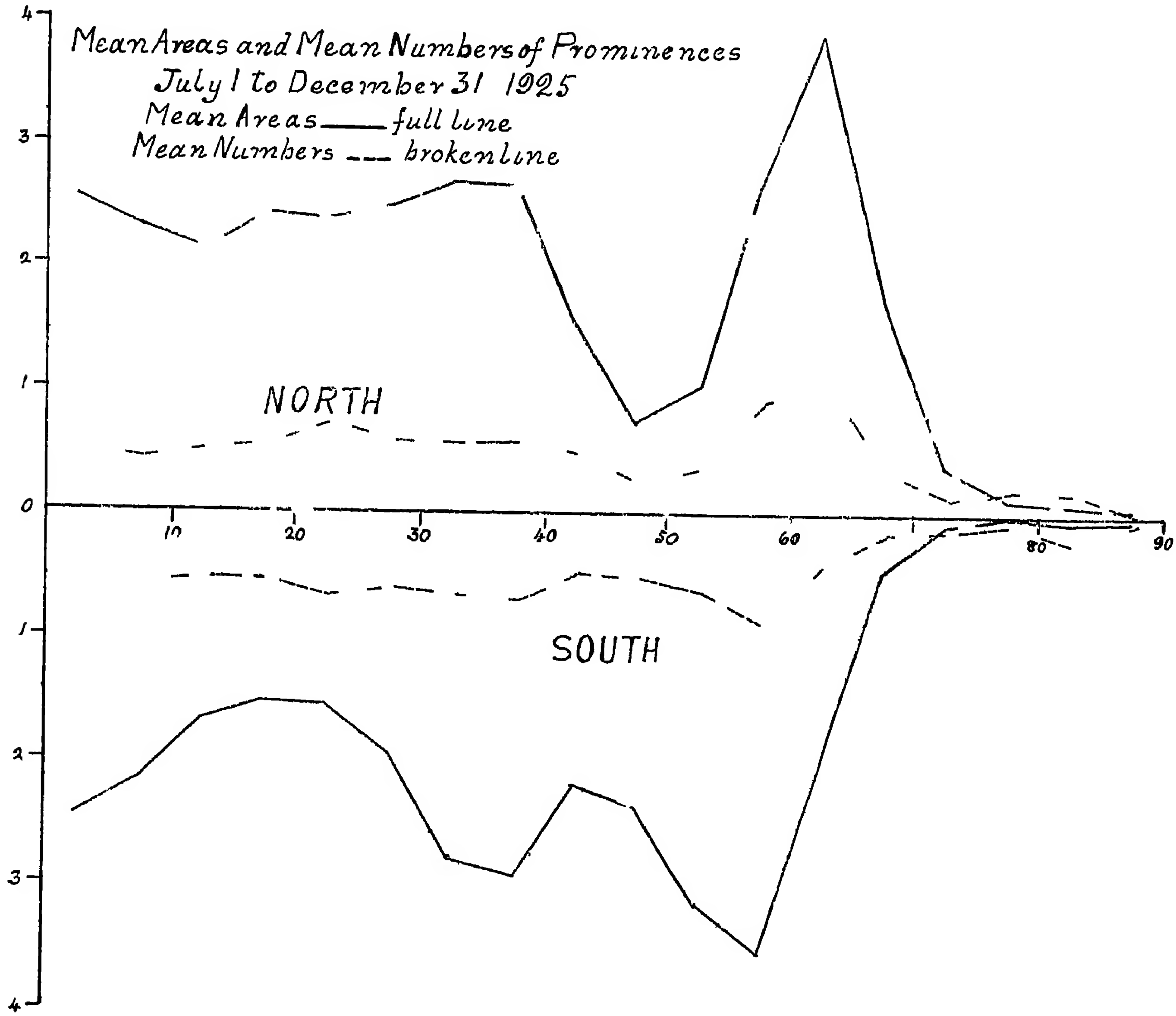
	Mean daily areas (square minutes).	Mean daily numbers.
North	3·18	8·40
South	3·08	8·34
Total ...	6·26	16·74

Compared with the previous half-year, areas have increased by 24 per cent the increase being more marked in the southern hemisphere. In the case of numbers, there is a slight decrease in the northern hemisphere, and an increase of 10 per cent in the southern.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 141 days of observation being counted as 118 effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North (Kodaikanal photographs only)	3·46	8·83
South do.	3·42	8·75
Total ...	6·88	17·58

The distribution of the prominences in latitude is represented in the following diagram in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude. The ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line. Compared with the previous half year there has been a decrease of activity near 45° which is more marked in the northern hemisphere than in the southern. The maximum of activity in the higher latitudes has advanced about 10° towards the poles.



The monthly, quarterly and half yearly areas and numbers and the mean height and mean extent of the prominences on photographs from all the co-operating observatories are given in Table 1. The unit of area is 1 square minute of arc. The mean height is derived by adding together the greatest heights reached by

individual prominences and dividing by the total number of prominences observed; the mean extent is derived by adding together the lengths of the base on the chromosphere of individual prominences and dividing by the total number of prominences.

TABLE I.—ABSTRACT FOR THE SECOND HALF OF 1925.

Months.	Number of days (effective).	Areas.	Numbers.	Daily Means.		Mean height.	Mean extent.
				Areas.	Numbers.		
1925						"	°
July	23½	137·8	379	5·9	16·1	36·4	5·22
August	22½	124·2	390	5·5	17·3	37·2	4·73
September	28¼	178·6	484	6·3	17·0	38·9	5·30
October	27	192·1	477	7·1	17·7	39·8	5·31
November	23	127·2	368	5·5	16·0	41·3	4·57
December	26¾	185·9	430	6·9	16·1	43·2	5·82
Third quarter	74¼	440·6	1253	6·0	16·9	37·6	5·10
Fourth quarter	76¾	505·2	1275	6·5	16·6	41·2	5·27
Second half-year	151	945·8	2528	6·3	16·7	39·5	5·18

Distribution east and west of the Sun's axis.

Both areas and numbers were in excess in the western hemisphere as will be seen from the following table:—

1925 July to December.	East.	West.	Percentage East.
Total number observed	1242	1286	49·1
Total areas in square minutes	446·2	499·6	47·2

Metallic prominences.

Twenty-nine metallic prominences were observed during the half-year. Their details are given below :—

TABLE II.—LIST OF METALLIC PROMINENCES OBSERVED AT KODAIKANAL, JULY TO DECEMBER 1925.

Date.		Hour I.S.T.		Base.	Latitude.		Limb.	Height.	Lines.
					North.	South.			
1925		H.	M.	°	°	°		″	
July	7	9	20	4		28	E	20	4924·1, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
September	2	8	2	3	33		W	25	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5316·8, 5383·6, 5535·1, D_1, D_2, 6677, 7065.
	4	9	33		18·5		W	60	b_1, b_2, b_3, b_4, D_1, D_2.
	14	9	0		18		W	85	4924·1, 5016, b_1, b_2, b_3, b_4, 5316·8, 5363·0, D_1, D_2, 6677, 7065.
	15	8	50	2	22		W	10	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, 5363·0, D_1, D_2, 6677, 7065.
	30	11	43			18·5	W	90	b_1, b_2, b_3, b_4, D_1, D_2.
October	2	8	50	3	19·5		W	90	4924·1, 5016, b_1, b_2, b_3, b_4, 5269·2, 5316·8, D_1, D_2, 6677, 7065.
	2	8	56		23		W	35	4924·1, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
	9	9	36			18	W	20	4924·1, 5016, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677.
	10	8	50		27		W	70	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	11	8	36		26		W	20	5016, b_1, b_2, b_3, b_4, 5316·8, 5363·0, D_1, D_2.
	14	9	41		27		E	10	b_1, b_2, b_3, b_4, D_1, D_2.
	14	10	50			25·5	W	15	4924·1, 5018·6, b_1, b_2, b_3, b_4, D_1, D_2, 6677, 7065.
	15	9	25		24·5		E	15	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
	16	9	12			24	E	15	b_1, b_2, b_3, b_4, D_1, D_2.
	19	9	2			27·5	W	30	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
	20	9	37			38·5	E	35	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	20	9	14			18	W	10	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
	20	8	58		14·5		W	40	4924·1, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
November	15	11	4			23	E	15	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
December	17	9	20			16	W	10	4924·1, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
	19	9	32		20·5		E	20	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 7065.
	20	9	30		35		E	30	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	20	9	50	1	21		E	10	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5316·8, 5363·0, D_1, D_2, 6677, 7065.
	23	10	5		33		E	15	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 7065.
	24	9	34		26		W	15	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	25	9	24			25	W	10	4924·1, 5016, b_1, b_2, b_3, b_4, 5316·8, 5363·0, D_1, D_2, 6677, 7065.
	25	8	24		22		W	20	6677, 7065.
	31	9	39	10		28	W	30	b_1, b_2, b_3, b_4, D_1, D_2.

The metallic prominences enumerated above were distributed in latitude as follows :—

	11°—20°	21°—30°	31°—40°	Mean latitude.	Extreme latitudes.
North	4	10	3	24°·1	14°·5 and 35°
South	4	7	1	24°·2	16° and 38°·5

Thirteen were in October and 9 in December. Ten were on the east limb and 19 on the west.

Displacements of the hydrogen lines.

Particulars of the displacements observed in the chromosphere and prominences are given in the following table :—

TABLE III.—DISPLACEMENTS OF HYDROGEN LINES.

Date.	Hour I.S.T.	Latitude.		Limb.	Displacement.			Remarks.
		North.	South.		Red.	Violet.	Both ways.	
1925	H. M.	°	°		A.	A.	A.	
July 2	8 54		85·5	E	1·5			At top.
2	9 46		11	W		Slight		
2	8 43	40		W	0·5			At top.
3	9 2		52	W	0·5			Do.
6	9 3	18		W	1			Do.
6	9 10	72·5		W	Slight			
7	8 50		22	W	1			At top.
8	10 5	86·5		W		1		
9	8 47	83		E		3		
9	9 9		20	W		Slight		
10	9 4	21		E		1		
10	9 2		10	W	1			
14	9 18		15	W	0·5	1		To red at top ; to violet at base.
14	10 8		13	W	1			At top.
15	9 41	40		E		Slight		Do.
22	9 46	16		W	1			Do.
25	9 45	23		W			1·5	
28	9 20	19		W	1			At top.
31	9 24		83	E		0·5		
August 1	10 8	43·5		E		1		
3	9 57	79		W		1		At base.
5	8 37	24		E	1·5			Do.
5	8 56		32	W	1			At top.
6	10 25	57·5		W	0 5			
11	9 20		26	W	1			
11	9 2	63·5		W	0·5			
14	8 58	67		E	Slight			
14	9 24	64		E	2			At base.
15	8 45	25		W		Slight		At top.
17	10 2		26	E		1		
17	9 57	39		W	Slight			At top.
18	8 49		31	W		Slight		
22	9 25	36·5		W		1		
24	10 16	76		W	0·5			
27	9 17		82 5	E		Slight		
27	9 16		82·5	W	Slight			
27	9 2	15·5		W	1·5			At top.
27	9 2	17		W		1		
30	8 4		11	W		Slight		At base.
31	11 2	44		E	Slight			Do.
31	10 50		54	W	1			At top

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1925		H.	M.	°	°		A.	A.	A.	
September	1	9	45	68		E	0·5			
	1	9	48	31		E		0·5		At top.
	1	9	12	27		W	1			Do.
	1	10	50	30		W	0·5			At base.
	2	8	2	33		W			2	
	3	9	4	70·5		E	Slight			
	3	9	14	15		E	Do.			
	3	9	2		71·5	W	Do.			
	4	9	13	20		E	Do.			
	4	8	58		34	W	1			At top.
	4	9	15		20	W	1			2 5 A at 9h 46m.
	4	8	42	59·5		W		0·5		At base.
	8	8	51		30·5	W		Slight		Do.
	8	8	40	55		W		Do.		Do.
	10	8	20	62		E	Slight			
	10	8	25	81·5		W		Slight		
	11	8	50	68		W	Slight			
	12	8	27		25	E	Do.			
	13	8	50	81		E	1			
	13	9	1	22		E	1			At top.
	13	8	58	18		W	1			Do.
	14	9	16	78		E	Slight			
	14	8	46	18·5		W	3	1		To red at top; to violet at base.
	14	8	52	19		W	8			At top.
	14	9	9	18		W	4			Do.
	14	9	28	20		W	2	1		To red at top; to violet at base.
	15	8	35	68		E	0·5			
	15	8	44	24		W	1			
	16	11	15	24		W		1		At top.
	21	10	0	12		W	1			Do.
	22	9	12		24	W	4			Do.
	22	8	48	60		W		Slight		
	24	9	20	38		E	Slight			At top.
	24	8	56		21	W	0·5			
	25	10	16		28	W	1			
	28	9	7	72·5		E		Slight		
	28	9	8	69		E	Slight			
	28	9	12	15		E		2		
	28	8	46	42		W	2			At top.
	29	10	10	14·5		E	2			
October	2	8	50	19·5		W	2	1		To red at top; to violet at base.
	2	8	56	23		W	2			At top.
	2	8	40	72·5		W		Slight		
	6	9	7	61		E	1			At base.
	6	8	54	13		W	0·5			At top.
	8	9	3	42		E	1			At base.
	9	8	46	19		W	1			At top.
	9	8	36	26		W	1			Do.
	10	9	2		16·5	W		Slight		Do.
	10	8	50	30		W		0·5		
	11	9	8	42		E		1		At top.
	12	9	8	23		E	1	2		To red at base; to violet at top.
	12	8	40	30		W	1·5			At top.
	13	9	40	35		E	1			Do.
	13	9	55		14	E	1	2		To red at base; to violet at top.
	14	9	35	25·5		E		0·5		At top.
	14	9	23	18·5		E	1			
	15	9	25	24·5		E	0·5	1·5		To red at base; to violet at top.
	15	8	44	31		W	Slight			
	16	8	58	58		E		Slight		
	16	8	58	53		E		Do.		
	16	8	59	11		E	Slight			
	16	9	8		13	E	0·5	1		To red at base; to violet at top.
	18	9	56		25	W	1			
	19	9	22	54·5		E		1		At top.
	19	9	20	axis		...	Slight			

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1925		H.	M.	°	°		A.	A.	A.	
October	19	9	2		27·5	W	1			At top
	20	9	24		24	E		0·5		
	20	9	26		34	E	1			At base.
	20	9	26		37	E	1			Do.
	20	9	9		16	W	Slight			
	20	9	4	14·5		W	1	1		To red at top ; to violet at base.
	20	8	54	30		W		1·5		
	20	8	54	25		W	1			
	20	8	47	77		W	Slight			
	21	9	58		3·5	E	Do.			
	21	9	24		43	W	Do.			
	22	9	45	27		E	Do.			At base.
	22	9	6	38		W	0·5			Do.
	22	9	40	83·5		W	Slight			
	29	8	50	19		W	Do.			At top.
November	6	8	55	54		E	Slight			
	6	9	0	15		E		1		
	6	8	50		17	W	Slight			
	6	8	42		25	W		1		At base.
	14	9	5	37		E	Slight	Slight		To red at top ; to violet at base.
	14	8	55		12	W		0·5		
	14	8	52	30		W		Slight		
	15	11	4		23	E	0·5			At top.
	18	10	11	20		E	2	1		Do.
	18	10	2	24·5		E		1		Do.
	18	10	1	30		E		Slight		Do.
	18	9	50		87	E		1		At base.
	18	9	47		64	W		1		Do.
	22	9	9		25	W	1			
	22	9	4		7	W	Slight			
	22	8	58	18		W	1			
	25	10	17	26·5		W	0·5			At top.
December	1	9	22		78	E	Slight			
	1	9	14	18		W	Do.			
	1	9	10	62·5		W		0·5		
	13	10	4	27		W	1	1·5		To red at top ; to violet at base.
	16	10	31	36·5		E	2			
	16	10	27	21		E	1·5			
	16	10	7		68	E	1			
	16	10	45		87	W		2		
	17	9	24	69		E	1			At base.
	17	9	28	38		E		0·5		
	17	9	16		19	W	1			
	18	8	56	77		E		1·5		
	18	9	32	30		E	1·5			
	18	9	38		20	E		1·5		At base.
	18	9	38		27	E	3			
	18	9	22		20	W	1			
	18	9	15	17		W	1·5			At top.
	18	9	15	21		W		0·5		At base.
	18	9	2	39		W		0·5		Do.
	19	9	32	19		E	2			Do. }
	19	9	32	20		E		1		At top. } seen in D_1, D_2 also.
	19	9	40		20	E	4	1·5		To red at base ; to violet at top.
	19	9	15		35	W		Slight		At base.
	20	10	22	30		E		1		Do.
	20	9	50	25		E	1			
	20	9	14	23		W	1	0·5		To red at top ; to violet at base.
	20	9	11	39		W	0·5			At top.
	21	9	3	65		W	1			Do.
	21	9	1	70		W	1			Do.
	21	9	20	33		E		3		Do.
	21	9	20	26		E	2			At base.
	21	9	40	23		E		1·5		At top.
	21	9	30	36		W	1			Do.
	21	9	4	29		W		1·5		At base.
	21	9	2	50		W	1			

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways	
1925		H.	M.	°	°		A.	A.	A.	
December	21	8	55	84		W		0·5		
	22	9	10	22		E	1			At base.
	22	8	50	23		W	Slight			
	23	9	50	34·5		E	3			Over middle of prominence
	24	9	10	83		E		Slight		
	24	9	42	26		W	1			At top.
	25	9	30		36	W	0·5			Do.
	25	9	20		25	W		0·5		At base.
	26	8	57		27	W		2		
	26	8	53	14		W	1			
	26	8	52	26		W	0·5			
	31	9	45	35·5		E		1		At top.
	31	9	33		23	E		4		At top ; 6A at 9^h 36^m.
	31	9	28		87	E	0·5			

The total number of displacements was 202 and they were distributed as follows :—

Latitude.	North.	South.
1°—30°	76	40
31°—60°	34	11
61°—90°	30	11
Total ...	140	62

East limb	86
West limb	115
Pole	1
Total ...	202

One hundred and twenty-four displacements were towards the red, 76 towards the violet and 2 both ways simultaneously.

Reversals and displacements on the Sun's disc.

Two hundred and eighteen bright reversals of the Hα line, 94 dark reversals of the D_3 line and 62 displacements of the Hα line were observed during the half-year. Their distribution is given below :—

	North.	South.	East.	West.
Bright reversals of Hα	132	86	95	123
Dark reversals of D_3	59	35	45	49
Displacements of Hα	34	28	24	38

Three-quarters of the number of displacements were towards the red.

Prominences projected on the disc as absorption markings.

Photographs of the Sun's disc in Hα light were available from all the co-operating observatories for a total of 179 days, which were counted as 172¼ effective days. The mean daily areas of Hα absorption markings (corrected for foreshortening) in millionths of the Sun's visible hemisphere and the mean daily numbers are given below :—

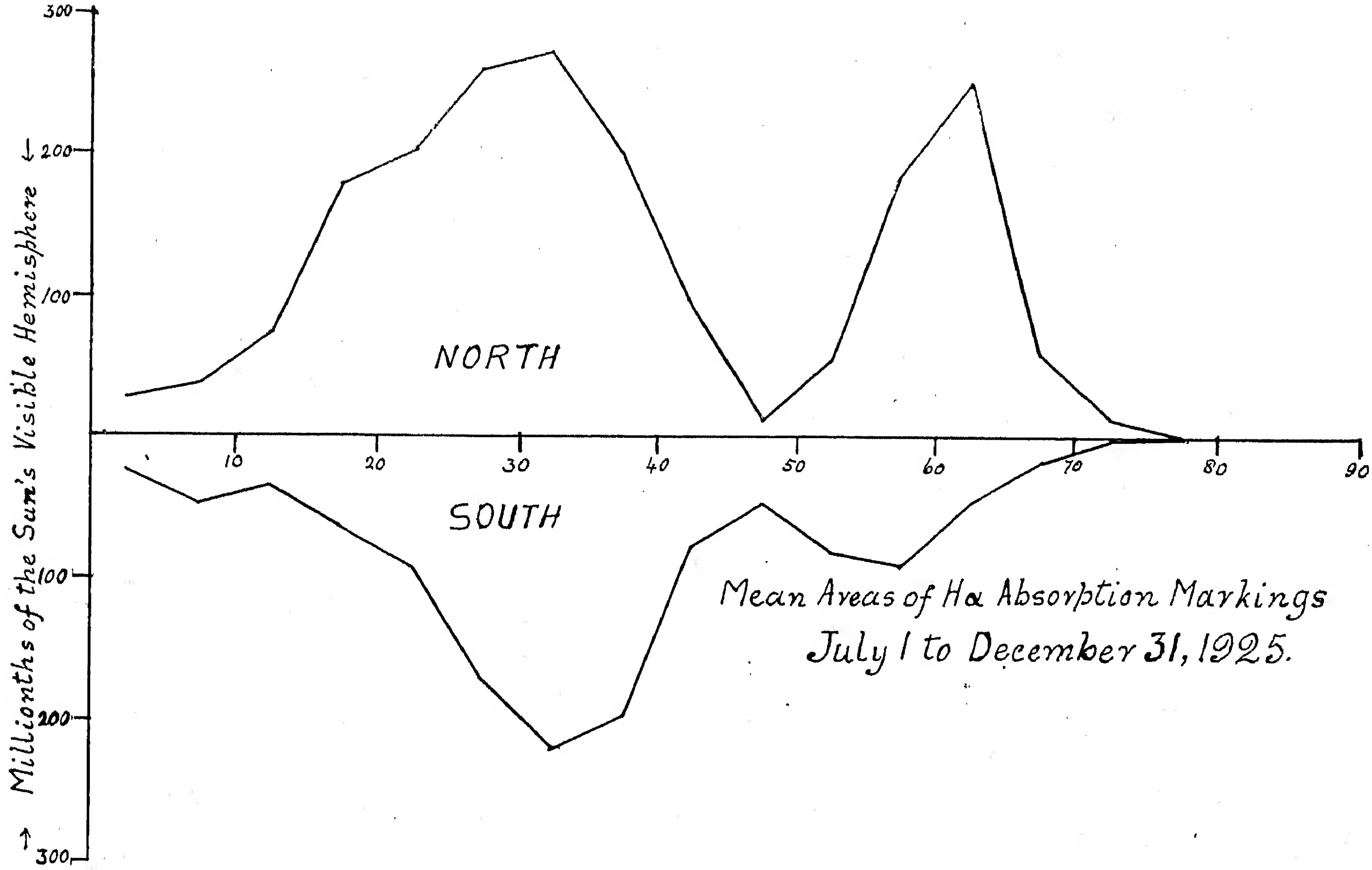
	Mean daily areas.	Mean daily numbers.
North	1917	14·4
South	1223	9·8
Total ...	3140	24·2

These figures indicate an increase of about 70 per cent compared with the previous half-year.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 120 days of observation being counted as 113½ effective days.

	Mean daily areas.	Mean daily numbers.
North (Kodaikanal photographs only)	1928	15·2
South do.	1241	10·2
Total ...	3169	25·4

The distribution of the mean daily areas in latitude is shown in the following diagram. The diagram shows two maxima at 30° and 60°, but in the southern hemisphere the second maximum is not so well developed.



As in the case of prominences at the limb, the activity is in excess in the western hemisphere, the percentage east being 48·23 for areas and 48·76 for numbers.

Thanks are due to the co-operating observatories for the photographs supplied by them.

THE OBSERVATORY, KODAIKANAL,
20th July 1926.

T. ROYDS,
Director, Kodaikanal and Madras Observatories.

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Date		Hour IST	Latitude		Limb	Displacement			Remarks
			North	South		Red	Violet	Both ways	
1925						A	A		
December	1	8 55	84		W		0		
	22	9 10	22		E	1			At l
	22	8 50	23		W	Slight			
	23	9 50	34 5		F	3			O [illegible] 1ll f p
	24	9 10	83		E		Slight		
	24	9 42	26		W	1			Att l
	25	9 30		36	W	0 5			D
	25	9 20		25	W		0		At l
	26	8 57		27	W		2		
	26	8 53	14		W	1			
	26	8 52	26		W	0 5			
	31	9 45	35 5		E		1		Att p
	31	[illegible] 33		23	E		4		Att p (A at [illegible])
	31	9 28		87	E	0 5			

The total number of displacements was 202 and they were distributed as follows —

Latitude		North	South
1 —30		76	40
31 —60		34	11
61 —90		30	11
	Total	140	62

East limb		86
West limb		115
Pole		1
	Total	202

One hundred and twenty four displacements were towards the red 76 towards the violet and [illegible] both ways simultaneously

Reversals and displacements on the Sun's disc

Two hundred and eighteen bright reversals of the Hα line 94 dark reversals of the D_3 line and 62 displacements of the Hα line were observed during the half year Their distribution is given below

	North	South	East	West
Bright reversals of Hα	139	79	95	123
Dark reversals of D_3	59	35	45	49
Displacements of Hα	34	28	24	38

Three-quarters of the number of displacements were towards the red

Prominences projected on the disc as absorption markings

Photographs of the Sun's disc in Hα light were available from all the co operating observatories for a total of 179 days which were counted as 172¼ effective days The mean daily areas of Hα absorption markings (corrected for foreshortening) in millionths of the Sun's visible hemisphere and the mean daily numbers are given below —

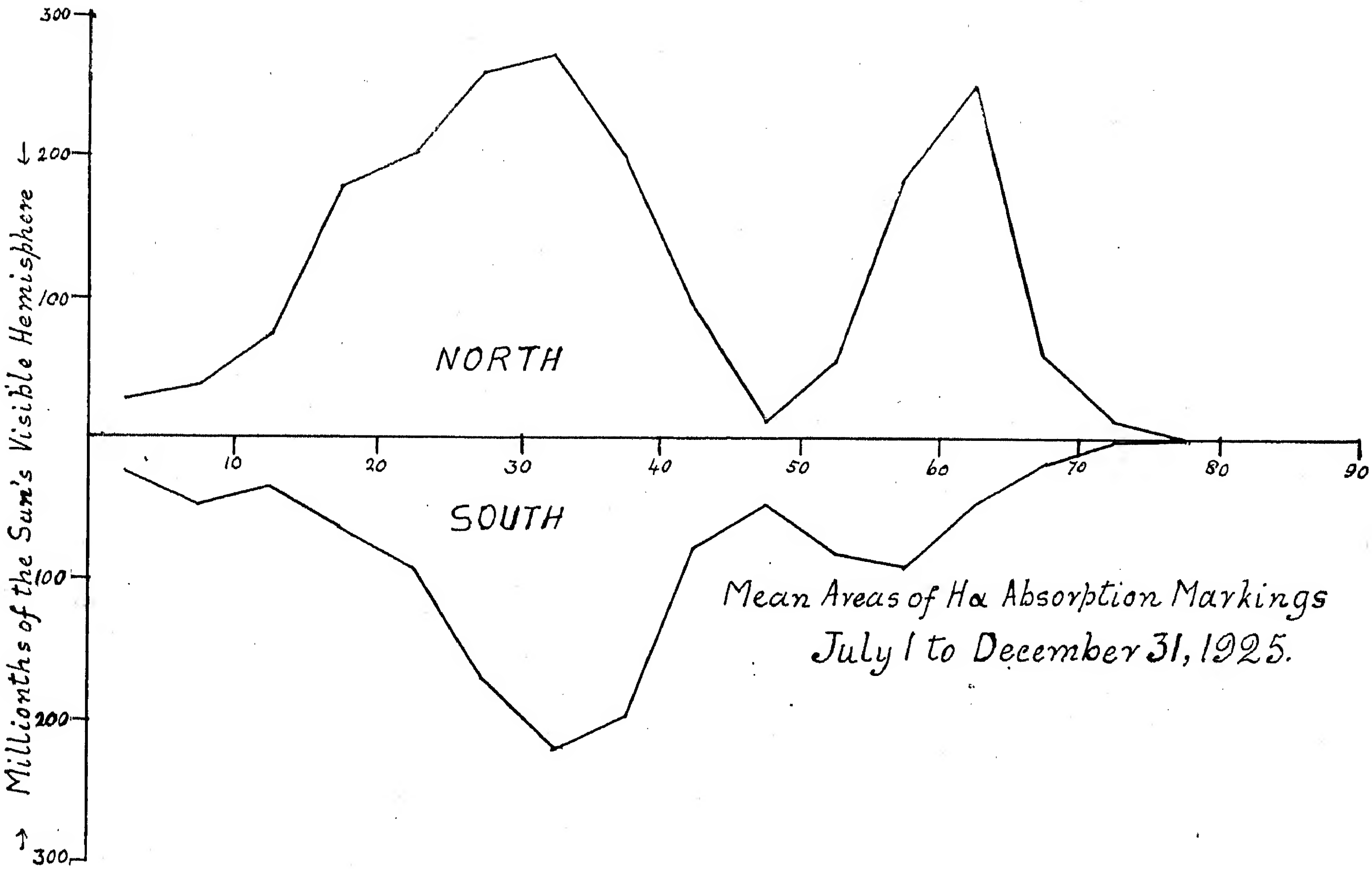
		Mean daily areas	Mean daily numbers
North		1917	14 4
South		1223	9 8
	Total	3140	24 2

These figures indicate an increase of about 70 per cent compared with the previous half-year.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 120 days of observation being counted as 113½ effective days.

	Mean daily areas.	Mean daily numbers.
North (Kodaikanal photographs only)	1928	15·2
South do.	1241	10·2
Total ...	3169	25·4

The distribution of the mean daily areas in latitude is shown in the following diagram. The diagram shows two maxima at 30° and 60°, but in the southern hemisphere the second maximum is not so well developed.



Mean Areas of Hα Absorption Markings
July 1 to December 31, 1925.

As in the case of prominences at the limb, the activity is in excess in the western hemisphere, the percentage east being 48·23 for areas and 48·76 for numbers.

Thanks are due to the co-operating observatories for the photographs supplied by them.

THE OBSERVATORY, KODAIKANAL,
20th July 1926.

T. ROYDS,
Director, Kodaikanal and Madras Observatories.

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Kodaikanal Observatory.

BULLETIN No. LXXX.

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE FIRST HALF OF THE YEAR 1926.

In pursuance of the programme of work adopted since 1st January 1923 under the auspices of the International Astronomical Union, all observatories taking spectroheliograms of the Sun have been asked to co-operate with the Kodaikanal Observatory by supplying copies of their photographs on those days when the Kodaikanal records are imperfect or wanting. In response to our requirements for the first half of the year 1926, the Mount Wilson Observatory supplied prominence plates for 19 days and Hα disc plates for 14 days; Meudon Observatory supplied K_3 disc plates for 9 days and Hα disc plates for 4 days.

When incomplete or imperfect photographs for the same day are available from more than one observatory, the best photograph is chosen as representing the solar activity of that day after weighting it according to its quality, and the remaining photographs are ignored.

The mean daily areas and numbers of prominences during the half-year are given below. The means are corrected for incomplete or imperfect observations, the total of 181 days when plates were available being reduced to 175½ effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North	4·62	9·37
South	3·46	8·46
Total ...	8·08	17·83

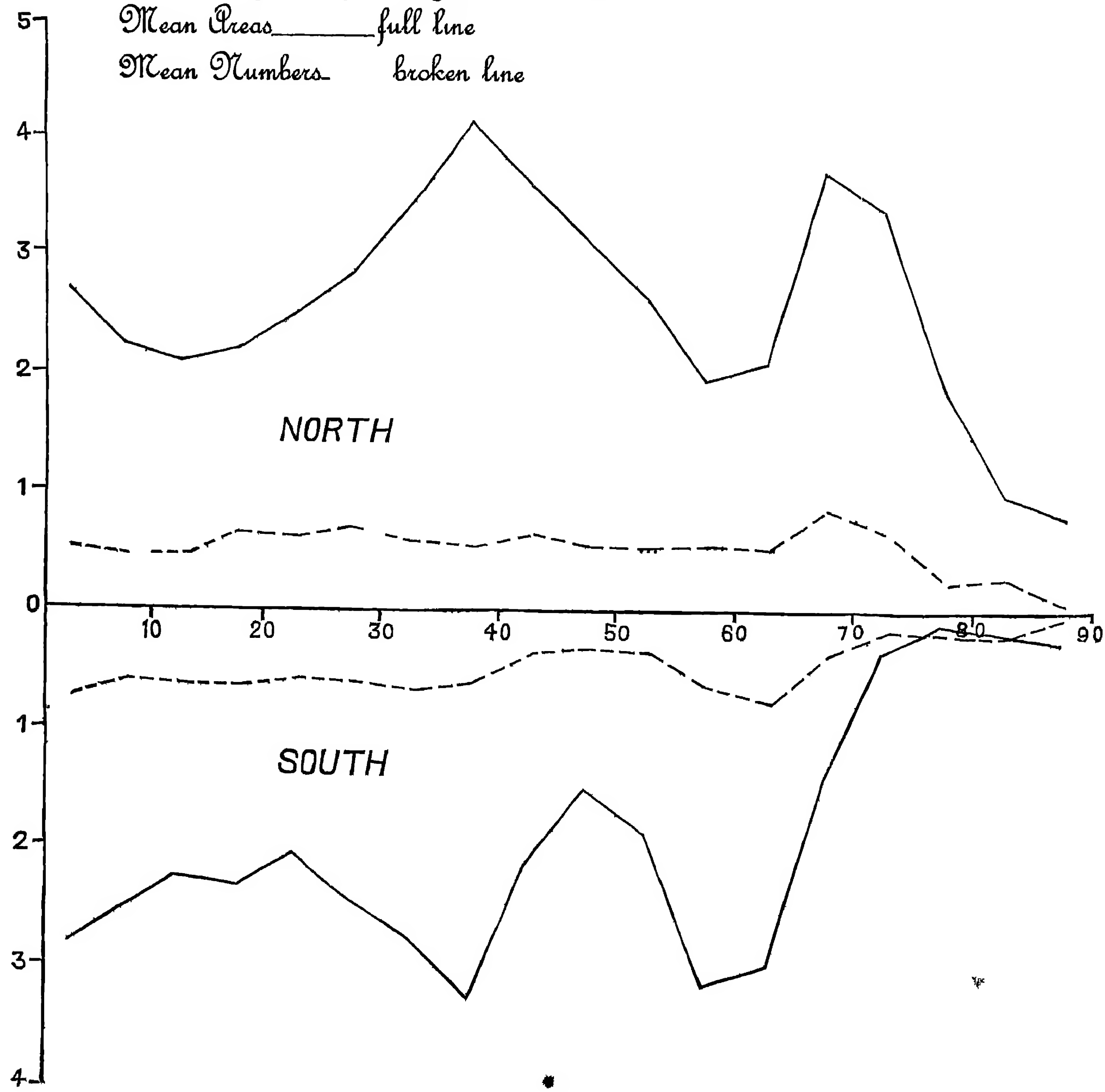
Compared with the second half of the year 1925, areas show an increase of 45 per cent in the northern hemisphere and an increase of 11 per cent in the southern. In the case of numbers, there is an increase amounting to 12 per cent in the northern hemisphere, and a slight increase in the southern. The excess of activity in the northern hemisphere has become more marked again.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 174 days of observation being counted as 167 effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North (Kodaikanal photographs only)	4·66	9·57
South do.	3·52	8·65
Total ...	8·18	18·22

The distribution of the prominences in latitude is represented in the following diagram in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude. The most active zone is now 35°–40° in both hemispheres. The peak in high latitudes has advanced 5° towards the poles compared with the last half of 1925 and in the advance towards the poles the southern hemisphere still lags about 10° behind the northern.

Mean Areas and Mean Numbers of Prominences
January 1 to June 30 1926



The monthly, quarterly and half-yearly areas and numbers, and the mean height and mean extent of the prominences on photographs from all the co-operating observatories are given in Table I. The unit of area is 1 square minute of arc. The mean height is derived by adding together the greatest heights reached by individual prominences and dividing by the total number of prominences observed; the mean extent is derived by adding together the lengths of the base on the chromosphere of individual prominences and dividing by the total number of prominences.

TABLE I.—ABSTRACT FOR THE FIRST HALF OF 1926.

Months.	Number of days (effective).	Areas.	Numbers.	Daily Means. Areas.	Daily Means. Numbers.	Mean height.	Mean extent.
1926.						"	°
January	31	262·9	515	8·5	16·6	45·3	6·37
February	28	235·3	472	8·4	16·9	42·8	6·23
March	31	283·1	581	9·1	18·7	46·5	5·75
April	29½	207·8	562	7·0	19·1	37·2	5·31
May	28¾	219·0	508	7·6	17 7	40·2	5·82
June	27¼	208·8	487	7·7	17·9	41·4	5·71
First quarter	90	781·3	1568	8·7	17·4	45·0	6·10
Second quarter	85½	635·6	1557	7·4	18·2	39·5	5·60
First half-year	175½	1416·9	3125	8·1	17·8	42 2	5·85

Distribution east and west of the Sun's axis.

Areas showed a slight excess in the western hemisphere, while the numbers showed a slight eastern excess' as will be seen from the following table :—

1926 January to June.	East.	West.	Percentage East.
Total number observed	1578	1547	50·5
Total areas in square minutes	678·0	738·8	47·9

Metallic prominences

One hundred and thirty three metallic prominences were observed during the half year more than four times the number in the previous half year The proportion in the northern hemisphere was (4 per cent

TABLE II —LIST OF METALLIC PROMINENCES OBSERVED AT KODAIKANAL JANUARY TO JUNE 1926

Date		Hour I S T	Base	Latitude		Limb	Height	Lines
				North	South			
1926		H M						
January	1	9 24			26	W	10	4924 1 5016 5018 6 b b b b 5316 8 5363 0 D D 6677 7065
	1	9 42	2		21	W	20	4924 1 b b b b 5316 8 D D
	1	9 13		15 5		W	50	6677 7065
	2	9 12			2	W	10	4924 1 b b b b 5316 8 D D
	2	9 55	5	33		W	25	4924 1 b, b, b b4 5316 8, D D
	4	9 10		21		W	150	4924 1 5016 5018 6, b b b b 5197 8 5234 8 [illegible] 5276 2 5284 3 5316 8 5328 7 5361 8 5363 0 [illegible] D D 6677 7065
	5	9 5	21	29 5		W	140	4924 1 5016 5018 6 b1 b2 b b 5234 8 5276 2 [illegible] 5535 1 D D2 6677 7065
	6	9 44	1	25 5		E	90	4924 1 5018 6, 5111 0 b1 b b b 5276 2 [illegible] 5363 0 D, D 6677, 7065
	7	9 10		26 5		E	90	4924 1 5016 5018 6 b b2 b b 5262 2 [illegible] 5363 0 D D
	8	9 5		38		E	45	b b b b 5316 8 D D
	8	9 15	3		24 5	E	15	b b b b D, D2
	10	9 20		20		E	10	4924 1 4978 6 5018 6 b, b, b b4 5197 8 5276 2 [illegible] 5363 0 D D 6677 7065
	11	10 10	4	20		E	10	4924 1 b b b3 b4 5316 8 D D
	12	8 55	1	17 5		E	145	b b b b 5316 8 D D
	13	9 55		20 5		E	15	b b b b4 D D
	14	9 20		21		E	20	4924 1 b b b b 5316 8 D, D
	14	9 16			31	W	10	4924 1 5018 6 b1 b b b4 5316 8 D D2
	15	8 55	9	24 5		E	40	b b b b 5316 8 D D
	15	8 58	5		19 5	E	90	4924 1 5016 5018 6 b1 b b b4 5234 8 [illegible] 5316 8 5363 0 5535 1 D D
	15	8 58	3		28 5	E	30	4924 1 5016, 5018 6, b b b b 5234 8 [illegible] 5316 8 5363 0 5535 1, D, D
	15	9 2	10	20 5		E	50	b b b b 5316 8, D D 6677 (Form well seen 1 D, D d 6677)
	17	9 20	3	31 5		E	30	4924 1 b b b b 5234 8 5316 8 D D
	18	9 30	3	31		E	15	4924 1 b b b b 5316 8 D D
	18	9 30	2	26		E	10	4924 1 b, b b b 5316 8, D D2 6677 7065
	18	9 10	5	27 5		W	40	4924 1 5016 5018 6 5139 8 b b b b4 5276 2 5316 8 5363 0 D D
	19	9 40	3	30 5		E	30	4924 1 5016 5018 6 b b, b2 b4, 5316 8 D, D
	19	9 28			24 5	W	20	4924 1 5016 5018 6 b b b b4, 5316 8 5363 0 D D
	19	9 15	6	29		W	20	5016 b b b b4 5316 8 D, D2 6677 7065
	20	9 48	3	30 5		E	20	4924 1 b, b b b4 5316 8 D, D 6677, 7065
	20	9 42	3		18 5	W	20	4924 1 5018 6 b b b b4 5316 8 D, D 7065
	20	9 3	3	21 5		W	10	4924 1 b1, b b b 5316 8 D D 6677 7065
	20	9 30	4	27		W	15	4924 1 5018 6 b b b b4 5284 8 5316 8 D D 6677 7065
	21	10 3		25		E	30	b b b b4, D, D
	22	9 42	10	20		W	30	4924 1 5016 5018 6 b b2, b, b4 5316 8, 5363 0 D D
	23	9 24	3		31 5	W	15	4924 1 5018 6 b, b2 b b4 5276 2, 5316 8, D, D
	24	9 5	4	22		W	15	4924 1 5016 5018·6 b b2, b3, b4 5197 8, 5234 8 5276 2 5284 2 5316 8 5363·0 5535 1 D D 6677 7065
	30	9 50	1		22 5	W	15	4924 1 5018 6 b1, b b3 b4 5197 8 5234 8 5276 2 5284 2, 5316 8, 5363 0, 5535 1 D, D 6677, 7065
	30	9 50	1		28 5	W	15	4924 1, 5018·6 b, b3 b, b4, 5197 8, 5234 8 5276 2, 5284·2 5316 8 5363·0 5535·1 D D 6677 7065
	31	9 2	27	28 5		W	155	4921 9 4924 1, 5018 6, b1, b2, b3, b4, 5197 8 5234 8 5269·8, 5276 2, 5316·8 5328·7 5363·0, 5535 1 D D 6677 7065

Date.		Hour I.S.T.		Base.	Latitude.		Limb.	Height.	Lines
					North.	South.			
1926.		H.	M.	°	°	°		"	
February	1	9	15	17	26 5		W	120	4924·1, 5018·6, b_1. b_2, b_3, b_4, 5234·8, 5276·2, 5316·8, D_1, D_2, 6677, 7065.
	2	9	0	3	24·5		E	70	b_2, b_2, b_3. b_4, 5316·8, D_1, D_2.
	2	8	50	13	34·5		W	110	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5197·8, 5234·8, 5276·2, 5284·2, 5316 8, 5363·0, 5535·1, D_1, D_2, 6677, 7065.
	3	10	15	3	25·5		E	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, 5337·0, 5363·0, D_1, D_2, 6677, 7065.
	3	10	40	4	30		W	40	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, D_1, D_2, 7065.
	4	10	11	5		19 5	E	25	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316·8, 5337·0, 5363 0, 5506·1, D_1, D_2, 7065.
	4	9	55	3		24·5	W	45	4924 1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316·8, 5363·0, D_1, D_2.
	4	9	18	4	35		W	30	4924 1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316·8, 5363·0.
	5	8	58	8	27		E	25	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	6	9	45	2	45		E	15	b_1, b_2, b_3, b_4, D_1, D_2
	6	9	45	2	40		E	10	4924·1, 5018 6, b_1, b_3, b_3, b_4, 5234 8, 5276·2, 5316·8, 5361·7, D_1, D_2. 6677, 7065.
	6	9	45	3	30·5		E	15	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5208·7, 5234·8, 5276·2, 5316 8, 5361·7, D_1, D_2.
	6	10	22	4		20	E	15	5018·6, b_1, b_2, b_3, b_4.
	6	9	8	8	29		W	40	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316·8. D_1, D_2.
	7	8	52	4	33		E	35	5016, 5018 6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 7065.
	7	8	43	2		18	E	65	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316·8, 5535·1, D_1, D_2, 6677, 7065.
	10	9	42	1	30·5		E	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316·8, 5363 0, D_1, D_2, 7065.
	10	9	42	2	25		E	20	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316·8, 5363·0, D_1, D_2, 7065
	10	9	42	2	20		E	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316·8, 5363·0, D_1, D_2, 7065.
	11	8	33	6		25	W	35	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5284·2, 5316·8, 5535·1, D_1, D_2, 6677.
	13	9	52	1	13 5		E	15	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276 2, 5316·8, 5363·0, D_1, D_2.
	13	10	27			29	W	15	b_1, b_2, b_3, h_4, D_1, D_2, 7065.
	13	10	27	1		21·5	E	15	b_1, b_2, b_3, b_4, D_1, D_2, 7065.
	14	9	58	5	17·5		E	20.	4924 1, 5018·6, b_1, b_2, b_3, b_4, 5197·8, 5204·8, 5206·2, 5208 6, 5227·2, 5316·8, 5328 7, 5363·0. D_1, D_2, 6677, 7065.
	14	9	58	3	26 5		E	10	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	15	10	12	4	17		E	15	5018·6, b_7, b_2, b_3, b_4, 5208·6, 5233·1, 5270·0. 5316 8, D_1, D_2, 6677, 7065.
	16	9	8	4	41		E	50	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 7065.
	16	9	31	2	28		W	10	5018·6, b_1, b_2, b_3. b_4, 5316·8. D_1, D_2.
	17	10	33	3	46·5		E	35	b_1, b_2, b_3, b_4, D_1, D_2.
	17	10	22	1	15 5		E	15	b_1, b_2, b_3, b_4, D_1, D_2
	18	9	32	2	33		E	10	5018·6, b_1, b_2, b_3, b_4. 5316·8, D_2, D_2.
	21	9	50	9		18·5	W	75	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234 8, 5276·2, 5316·8, D_1, D_2, 6677, 7065.
	21	9	30	3	9·5		W	10	4924 1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_2, 6677. 7065.
	22	10	0	7		33·5	E	40	4924·1, b_1, b_2, b_3, b_4, 5316.8, D_1, D_2.
	22	9	16	2		19	W	45	5018 6, b_1, b_2, b_3, b_4, 5270·1, 5316·8, D_1, D_2.
	23	8	40	4		36	E	65	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	23	8	58	8	16		W	40	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	24	9	30			16	W	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316 8, 5363·0, D_1, D_2, 6677, 7065.
	24	9	5	20	32		W	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316·8, 5363·0, 7065.
	25	9	33	4		26	E	15	5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, 5363·0, D_1, D_2.
	25	9	35	4		30	E	10	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677.
	26	8	57			25	E	10	b_1, b_2, b_3, b_4, D_1, D_2.
March	3	9	45	3		16·5	E	10	4924·1, 5018 6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316·8, 5363·0, D_1. D_2.
	4	9	2	5	23·5		E	15	4924·1, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.

Date.	Hour. I.S.T.	Base.	Latitude. North.	Latitude. South.	Limb.	Height.	Lines.
1926.	H. M.	°	°	°		″	
March 5	9 12	4	20		E	35	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316·8, 5363·0, D_1, D_2, 7065.
6	10 15	1	8·5		E	10	b_1, b_2, b_3, b_4, D_1, D_2, 7065.
6	9 30	1	34·5		W	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5316·8, D_1, D_2, 7065.
8	9 16	2	18		E	20	5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
9	9 3	2	19		E	30	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
10	9 28	4	29		E	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316·8, 5363·0, D_1, D_2.
12	8 55	2		31	W	20	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5197·8, 5234·8, 5276·2, 5284·3, 5316·8, 5363·0, 5425·5, 5535·1, D_1, D_2, 6677, 7065.
13	10 55	2	20		E	15	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316·8, 5337·0, 5363·0, D_1, D_2.
14	8 31	3	21·5		E	25	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5316·8, D_1, D_2, 6677, 7065.
15	9 20	5	34·5		E	20	5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
20	9 45	1		0·5	W	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316·8, 5363·0, D_1, D_2.
21	9 0	4		30	E	20	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, D_1, D_2.
22	8 50	5	24·5		W	40	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
23	9 26	4		42	E	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316·8, 5363·0, D_1, D_2, 7065.
23	10 10	2		18	W	10	4924·1, 4934·2, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316·8, 5363·0, 5527·0, D_1, D_2, 6677, 7065.
23	10 37	2	13		W	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316·8, 5363·0, D_1, D_2, 6677, 7065.
24	8 55	4		42	E	40	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
26	9 16		8		W	10	b_1, b_2, b_3, b_4, D_1, D_2.
27	9 36	6	21		W	15	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5197·8, 5204·7, 520[illegible], 5234·8, 5270·6, 5276·2, 5316·8, 5363·0, D_1, D_2, 7065.
28	9 0	4	20		W	30	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
29	8 49	2		28	W	30	4924·1, 4934·2, 5016, 5018·6, b_1, b_2, b_3, b_4, 5197·[illegible], 5204·7, 5206·2, 5208·5, 5234·8, 5269·7, 5276·2, 5284·3, 5316·8, 5328·2, 5363·0, 5535·1, D_1, D_2, 6677, 7065.
29	8 36	3	48·5		W	15	4924·1, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
April 8	9 40	7		18·5	E	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316·8, 5363·0, D_1, D_2, 6677, 7065.
12	8 53		32		E	10	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
12	8 30	4		11	W	15	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5316·8, 5535·1, D_1, D_2, 6677, 7065.
17	9 46	1		10·5	W	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5197·8, 5234·8, 5269·7, 5276·2, 5284·3, 5316·8, 5328·2, 5363·0, D_1, D_2, 6677, 7065.
18	9 45	11		27·5	W	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316·8, 5363·0, D_1, D_2, 7065.
19	8 44	5		22·5	W	10	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
21	10 6	1		22·5	E	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316·8, D_1, D_2, 6677, 7065.
23	9 15	4	40		W	15	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316·8, 5363·0, D_1, D_2.
24	9 44	4	40		W	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316·8, 5363·0, D_1, D_2.
25	8 50	4		33	E	15	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
25	8 28	8	44		W	40	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, 5363·0, 5535·1, D_1, D_2.
26	9 9	2	33		W	10	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
28	10 46		10		E	10	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
29	9 20	5		20·5	E	10	4922·0, 4924·1, 4934·2, 4957·5, 5018·6, 5031·2, 5107·[illegible], 5110·6, b_1, b_2, b_3, b_4, 5197·7, 5204·7, 5206·3, 520[illegible], 5227·4, 5234·8, 5269·9, 5270·6, 5276·2, 5284·2, 531[illegible], 5328·2, 5337·0, 5341·2, 5363·0, 5371·7, 5397·3, 540[illegible], 5425·4, 5429·9, 5434·8, 5446·8, 5535·1, D_1, D_2, 6677, 7065.
30	9 3	5		25·5	E	10	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 7065.

Date.		Hour. I.S.T.		Base.	Latitude.		Limb.	Height.	Lines.
					North.	South.			
1926.		H.	M.	°	°	°		″	
May	2	9	45	1	22·5		E	15	b_1, b_2, b_3, b_4, D_1, D_2, 7065.
	6	9	38		33		E	10	b_1, b_2, b_3, b_4, D_1, D_2.
	9	9	22	2		32	E	15	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	9	9	35	1	17·5		W	25	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677.
	12	9	10	4		22	W	10	5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
	20	10	1	6	22		W	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316·8, 5363·0, D_1, D_2, 6677, 7065.
	23	9	15	7	31·5		W	30	5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	31	9	25	3		17·5	E	10	b_1, b_2, b_3, b_4, D_1, D_2.
June	11	9	50			15	W	10	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677.
	15	9	21	3	17·5		W	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5197·8, 5234·8, 5276·2, 5316·8, 5363·0, D_1, D_2, 6677, 7065.
	15	9	49	1	25·5		E	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316·8, 5363·0, D_1, D_2, 6677, 7065.
	23	9	9	4	22		E	15	4924·1, 5016·0 5018·6, b_1, b_2, b_3, b_4, 5270·6, 5316·8. 5363·0, D_1. D_2, 6677, 7065.
	24	9	20		26		E	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316·8, 5363·0, D_1, D_2, 7065.

Their distribution in latitude is shown below :—

	1°—10°	11°—20°	21°—30°	31°—40°	41°—50°	Mean latitude.	Extreme latitudes.
North	4	19	35	22	5	26°·7	8° and 48°·5
South	1	15	23	7	2	23°·9	0°·5 and 42°

Seventy-three metallic prominences were on the east limb and sixty on the west.

Displacements of the hydrogen lines.

Particulars of the displacements observed in the chromosphere and prominences are given in the following table :—

TABLE III.—DISPLACEMENTS OF HYDROGEN LINES.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1926.		H.	M.	°	°		A.	A.	A.	
January	1	9	4	70		E		0·5		At base.
	1	9	24		26	W	1			At top.
	1	9	13	14·5		W	1			Do.
	2	9	8		18	W	1			Do.
	2	8	52	61		W		Slight		At base.
	2	8	48	78·5		W		Do.		Do.
	3	9	14		16	W	1			At top.
	3	9	8	21		W	3			Do.
	3	9	4	29		W	1			Do.
	3	9	2	32		W		1·5		At base.
	4	9	30	12		W	1			At top.
	4	9	30	16		W		0·5		Do.
	4	9	30	26		W	2			Do.
	4	9	10	30		W		1		At base.
	4	9	10	34		W	1			At top.
	4	8	32	82		W	1			Do.
	5	9	18		38	W		0·5		At base.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1926.		H.	M.	°	°		A.	A.	A.	
January	5	9	10	20		W		1		
	5	9	5	29·5		W	2	3		To red at base; to violet at top.
	5	9	1	50		W	Slight			
	6	10	33	66		E		1·5		At top.
	6	9	37	29·5		E		Slight		
	6	9	41	25·5		E	2	3		To red at base; to violet at top.
	6	9	44	25·5		E	6			At base.
	6	10	55	22		W	Slight			At top.
	7	8	56	49		E	0·5			Do.
	7	9	31	30		E	1			Do.
	7	9	22	21		E	1			Do.
	7	9	00	33		W	2			Do.
	8	8	55		29	W		2		
	10	9	58	83·5		E		1		At top.
	11	10	24	34		E		0·5		Do.
	11	9	55	21		E		1		Do.
	12	9	0		25	W	Slight			Do.
	12	9	0	25		W	Do.			Do.
	13	9	47	32·5		E	2			At base.
	13	9	34		11	W	Slight			At top.
	14	8	46	85		E	Do.			Do.
	14	9	34		16	E		1·5		Do.
	14	9	16		32	W		1·5		At base.
	14	9	0	2·5		W	1			At top.
	14	8	56	24		W		0·5		At base.
	15	8	52	54·5		E		0·5		
	15	8	40	28		W		0·5		
	16	9	22	16		E		1		At top.
	16	9	22	18		E	1·5			At base.
	16	9	22	20·5		E		2		At top.
	16	8	58	48		W		Slight		At base.
	17	8	50	83		E	0·5			At top.
	17	9	20	23·5		E	1			Do.
	17	9	20	20		E		0·5		At base.
	17	9	28	3		E	Slight			Do.
	17	9	34		19	E	1			At top.
	17	8	55	46		W		Slight		At base.
	18	8	44	88		E	Slight			At top.
	18	9	30	26		E	2·5	2		To red at base; to violet at top.
	18	9	30	20		E	2			At top.
	18	9	24		13	E		1		Do.
	18	9	45	33		W		0·5		Do.
	18	9	10	27·5		W	3	2		To red at top; to violet at base.
	18	9	50	24		W	2			At top.
	19	9	2	84		E		1		At base.
	19	9	0	77		E		Slight		No prominence.
	19	9	40	30·5		E		1·5		At top
	20	9	16	69·5		E		0 5		No prominence.
	20	9	48	30 5		E	1			At base.
	20	10	20		61	E	1·5			Do.
	20	9	32	23		W	1			At top.
	20	9	35	19		W	0·5			Do.
	21	11	4		36	W	2	2		Do
	21	11	4		22·5	W	1			At base.
	21	11	7		16·5	W	1·5			At top.
	23	8	52	80 5		E		Slight		
	23	9	39	23		E		1·5		At top
	23	9	30		59·5	W		Slight		No prominence.
	23	9	28		48·5	W	Slight			At top.
	23	9	4	32		W	1			Do.
	23	9	1	40		W	0·5			Do.
	23	8	57	58·5		W		Slight		
	24	9	20		46	W	2			At top.
	24	9	5	20		W		Slight		
	30	9	25	83		E	0·5			In chromosphere.
	30	9	20	28		E		Slight		At top.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1926.		H.	M.	°	°		A.	A.	A.	
January	30	9	42		30	W			2	At base.
	30	9	42		29	W		2		Do
	30	9	42		28	W	2			At top.
	30	9	39		22·5	W			2	Over the whole prominence.
	30	9	35		21	W		2		At top.
	30	9	35		20·5	W		Slight		Over the whole prominence.
	30	9	34		19	W		1		At base.
	31	9	2	22·5		W	3			At top.
	31	9	4	34·5		W	1			In the middle of prominence.
February	1	8	59	50·5		E	Slight			
	1	8	48		54	E	Do.			
	1	8	45		74	E	Do.			
	1	9	13	14		W	3			
	2	8	55		62	W		Slight		
	3	10	22	27		E	2	3		At base.
	3	10	0	24		E	Slight			Do.
	4	10	33		66	E	1			In chromosphere.
	4	9	37	12		W	1			At top.
	4	9	12	51·5		W	3			Do.
	5	8	54	25		E	Slight			
	5	8	46		18·5	E	Do.			At top.
	6	9	50	32		E	1			Do.
	6	10	17		19·5	E			Slight	Do.
	6	9	30		19·5	W	Slight			Do.
	7	8	43		19	E	Do.	Slight		To red at base ; to violet at top.
	8	8	43	67		E		0·5		At base.
	8	8	38	49		E	1			At top.
	8	9	11	24		E	0 5			Do.
	8	9	6		7	E		Slight		Do.
	8	9	6		13	E	1			Do.
	8	8	49	53·5		W	Slight			Do.
	9	9	3	54·5		W		2		Do.
	10	10	11	62		E	1			At base.
	10	9	49	17		E		1		At top.
	10	9	30		12 5	E	1	2		Do.
	10	9	4		79·5	W	Slight			Do.
	11	8	33		33	W		1		
	11	8	33		24	W		1		At north end.
	12	8	58	76·5		E		0·5		At top.
	12	8	55	72		E		Slight		No prominence.
	12	8	52	69		E	Slight			At top.
	12	9	0	71		W	0·5			Do.
	13	10	7	40·5		E		3		Do.
	13	10	7	40 5		E		Slight		At base.
	13	10	5	21·5		E		1		At top.
	13	9	59	1		E	1			Do.
	13	9	22		17	E	1			In a filament in the middle portion.
	14	9	32	51		E	1			At top.
	14	9	6	38		E	1	1·5		Do.
	14	9	40	12		E	3	2		To red at top ; to violet at base.
	14	10	6	10		E	1			At top.
	14	9	20	30		W	Slight			Do.
	14	9	18	60		W		0·5		At base.
	14	9	15	68		W	0·5			
	15	9	42	39		E	1	1		To red at base ; to violet at top.
	15	10	12	17		E	1	2		Do.
	16	9	56	44		E		1		At top.
	16	10	0	29		E		0·5		Do.
	16	9	28	46		W		Slight		At base.
	16	9	20	86		W	0·5	1		To red at top ; to violet at base.
	17	10	38	63		E		1		At top.
	17	10	32	47·5		E	1·5			At base.
	17	10	32	47		E		0·5		At top.
	17	9	38		27	E		Slight		Do.
	18	9	0	50		E	1	1		To red at top ; to violet at base.
	18	9	12	25		W	1·5	1		Do.

Date.		Hour. I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1926.		H.	M.	°	°		A.	A.	A.	
February	19	8	50	35		E	Slight			
	20	9	22		18	W		Slight		At base.
	20	9	15	13		W	1			At top.
	21	9	50		18	W	1			Do.
	21	9	40	0·5		W	1			Do.
	22	8	53	43		E	Slight			Do.
	22	9	0	61		W	1			Do.
	23	8	38		69	W	2			
	25	8	50	62·5		E		0·5		
	25	9	2		26	E		2		Over whole of prominence.
	25	9	35		26	E	2			At base.
	25	9	10	25		W	0·5			At top.
	26	8	57		18	E		Slight		Do.
	28	9	28	7		E	0·5			Do.
	28	9	14	7		W	2			Do.
	28	9	14	12		W		1		At base.
	28	9	8	20		W	1			At top.
March	1	9	16	49		W	1			Do.
	2	8	42	14		W	Slight			Do.
	3	9	55	24		E		1		Do.
	3	9	8		60	W			0·5	Do.
	4	9	45	37·5		E	Slight			Do.
	4	9	2	21		E		1		At base.
	4	9	2	25		E	3			At top.
	4	9	16	68		W	Slight			Do.
	5	9	1		19	E		2		At base.
	5	8	56		40	W	Slight			Do.
	5	9	21		4	W		Slight		
	6	9	58	20		E	0·5			At base.
	6	10	4	15		E		1		At top.
	6	10	7	12		E			Slight	Do.
	6	10	22		16	E		2		Do.
	7	10	0	35·5		E	1			Do.
	7	10	25		11·5	E	1			Do.
	7	10	6	41·5		W	0·5			Do.
	8	9	30		34·5	W	1			Do.
	8	9	26	42·5		W		1		At base.
	9	9	27	26		E		3		At top.
	9	9	40		50·5	W	1·5			
	10	9	28	28·5		E		1		A little below top.
	10	9	27	26		E	1			In the middle of prominence.
	11	11	34	83		E	0·5			At top.
	12	8	40	35		E	1			Over lower part of prominence.
	12	8	27		54	E	2			No prominence.
	12	8	55		31	W		0·5		At base.
	13	11	27	41		E	2·5	1		Do.
	13	10	51	20		E			0·5	At top.
	14	8	50	45		E	Slight	Slight		To red at base ; to violet over middle part.
	14	8	31	25		E		1		At base.
	14	8	31	20		E	2			At top.
	14	8	25		60	W	Slight			At south end of Pr.
	15	9	10	50		E	1			At top.
	15	9	20	24		E		1		At base.
	16	9	23		66	E	1			
	16	9	15		78	W		Slight		No prominence.
	16	9	4	26		W	Slight			
	16	9	0	47		W	Do.			
	17	9	19		49	W	1			At top.
	17	9	21		43·5	W		1		Do.
	17	9	40	19		W	1			Do.
	18	9	0	53		W		Slight		At base.
	20	9	45		1	W	0·5			Do.
	21	8	48	71·5		E		Slight		Do.
	21	9	20		71·5	W	Slight			At top.
	21	9	4	18·5		W	0·5			Do.
	21	8	53	51		W	1			Do.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1926.		H.	M.	°	°		A.	A.	A.	
March	22	8	31	80		E		Slight		
	22	8	29	61·5		E	Slight			
	22	9	2	37·5		E	Do.			
	22	8	40	33·5		W	Do.			
	22	8	37	50		W		Slight		
	23	9	53	51·5		E	Do.			At base.
	23	9	21		60	E			Slight	At top.
	23	10	6		22	W	1			Do.
	23	10	10		19	W		3		Do.
	23	10	10		18	W	1·5			Do.
	23	10	32		9	W	1			Do.
	23	10	37	13		W	1	Slight		Do.
	24	9	3		23	E	Slight			
	24	8	40		79·5	E	Do.			
	24	8	47	28		W	1			At base at southern end of prominence.
	25	8	59	46·5		E	1	Slight		To red at top on the whole of the filament; to violet below it on the head of the main portion.
	25	9	56		8·5	E		1		At top.
	25	9	55		12	E		Slight		Do.
	25	10	5		47·5	E	1			In chromosphere.
	26	8	56		30	E		Slight		At top.
	26	9	10		21	W	1			
	26	9	20	61		W	Slight			
	27	10	29		51	E	0·5			At base.
	27	10	33		76	W		Slight		At top.
	27	10	6		17	W	0·5			Do.
	27	9	33	19		W	Slight			Do.
	27	9	39	22		W	1			Do.
	28	8	47	32·5		E		1		Over whole prominence.
	28	8	44	9·5		E		Slight		
	28	8	53		38·5	W	Slight			At top.
	29	8	28	67		E			Slight	
	29	8	44		28	W	1	1		To red at base; to violet at top.
	29	8	42	11		W		Slight		
	29	8	32	74		W		Do.		At base.
	30	8	48		1	E	2			No prominence.
	30	9	3	34		W	0·5			
	31	9	38	15·5		E		1		At top.
	31	8	59	64		W		Slight		At base.
	31	9	0	67		W	Slight			At top.
April	1	9	35	25		W	Slight			At top.
	2	8	42	31		E	Do.			
	2	8	48		11	E			Slight	
	3	8	50	12		E	Slight			At base.
	3	8	45		36·5	E	1·5			
	4	9	23	32		E	1			At base.
	4	9	12		11·5	E	1			At top.
	4	9	31		17	W	0·5			Do.
	5	9	12	14		E	Slight			At base.
	5	9	43	47·5		W	1			At top.
	8	9	29	1		E		1		At base.
	8	9	38	15		E	1	2		Do.
	8	9	38	17		E		2		At top.
	8	9	13		29·5	W	1			At top of two prominences.
	9	8	34		43	E	Slight			
	9	8	46	42		W		1		
	10	9	31	22		E		1		At top.
	10	9	22		32	W	2			Do.
	11	8	47		21·5	E	3			Over whole prominence.
	11	8	44		31·5	E		Slight		At top.
	11	8	55		26	W		0·5		No prominence.
	12	8	38		9	W		Slight		
	12	8	38		13	W		2		At top.
	12	8	30	67		W	Slight			At base.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1926.		H.	M.	°	°		A.	A.	A.	
April	14	9	0		32	E		1		At top.
	15	9	37		46	W		1		At base.
	15	9	21	3·5		W	2			At top.
	15	9	22	3·5		W	3			
	15	9	12	42·5		W	Slight			At top.
	15	9	12	49		W	1			Do.
	16	8	38		82	E	0·5			No prominence.
	17	10	25		33·5	E		3		At top.
	17	9	44		10·5	W	1·5			Do.
	18	9	10		35	E		1		Do.
	18	9	32		23	W		2		Do.
	18	9	56	18		W	1			Do.
	19	8	37	84		E	2			
	19	8	36	77		E	Slight			
	19	8	50	51·5		E		Slight		
	19	8	47		59·5	W		Do.		
	20	8	51		4	E		Do.		
	20	9	2		11	W		Do.		
	21	10	6		22	E		2		At top.
	21	10	6		22·5	E	1			At base.
	21	9	56		65·5	W	1	1		To red at top; to violet at base
	21	9	42		17·5	W	2			At top.
	21	9	31	30		W	1			Do.
	22	9	23		54	E	1			At base.
	22	9	23		54·5	E		1		At top.
	22	9	50	26·5		W		0·5		At base.
	23	9	18		20	W	Slight			At top.
	24	9	48	23·5		W		Slight		At base.
	25	8	18	79		E		Do.		
	25	8	42	50		E	1			
	25	8	37		50	W		Slight		At base.
	25	8	28	46		W		2		At top.
	26	8	48	65·5		E		Slight		
	26	8	47	55·5		E	Slight			
	26	8	46	52		E			Slight	More to red.
	26	8	38		14	E		Slight		At base.
	26	8	33		46	E	Slight			
	26	9	0		26	W	Do.			At base and southern end.
	26	8	52	76		W		2		
	27	9	7		52	W		Slight		At base.
	27	9	10		36	W		1		At base.
	28	8	25	84		E		Slight		
	28	8	46	10		E	1			
	28	8	46		10	E	1			
	28	8	58		24	E		0·5		
	28	9	1		84·5	E	2			No prominence.
	28	9	1		85·5	E			0·5	
	28	8	38		49	W		Slight		
	28	8	31	57		W		Do.		
	29	9	16		18	E	2	1		At base.
	29	9	16		19·5	E	3	2		On the whole prominence.
	29	9	17		21·5	E	3	1		In places.
	29	9	5		85	W		1		At top.
	29	9	5		84·5	W	2			Do.
	30	8	47	50·5		E		Slight		
	30	9	3		19	E	1			
May	2	9	31	30		W		1		At top.
	2	9	28	39		W		1		At base.
	3	8	39	35		E	Slight			
	3	8	43		33	W		Slight		
	5	8	52		29	W		0·5		At base.
	6	9	36	27		E	1			Do.
	7	9	5		20	E	0·5			
	7	9	0		73·5	E		0·5		
	8	10	11	21		E	2			At top.

Date.	Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
			North.	South.		Red.	Violet.	Both ways.	
1926.	H.	M.	°	°		A.	A.	A.	
May 8	10	17		22·5	E		Slight		At base.
9	9	22		39	E	Slight			
9	9	21		67	E	2			
9	9	20		83	W	Slight			
9	9	25		9	W		3		No prominence.
9	9	26	13		W		Slight		
9	9	35	17·5		W	1	1		To red at top; to violet at base.
10	9	50	29		E		Slight		At top.
10	9	40		18	W		Do.		Do.
10	9	37	25		W	Slight			
11	9	18	29		E	2			At top.
11	9	55		67	W		1		Do.
19	9	22	17		E	1·5			Do.
19	9	16	15		W	1			Do.
20	9	57	24		W		3		At base.
26	9	22	50		E	1			At top.
29	9	20		30	W	Slight			Do.
29	9	9	87·5		W	Do.			At base.
30	8	48		61	W	0·5			At top.
30	8	38	33		W	1			Do.
31	9	7		26·5	W	2			Do.
June 3	9	23	27·5		E		3		At top.
3	9	21	24·5		E	3			At base.
3	9	6		28	E	1			Do.
6	9	2	68		E	1			At top.
9	10	15		0·5	E	1			At base.
11	9	58		11	E		Slight		At top.
11	9	50		17	W	Slight			
13	9	20	33		W	0·5			At top.
15	9	45	25		E		1		Do.
15	9	21	17·5		W			3	
17	10	49	67		E		2		At top.
17	10	45	30·5		E		1		Do.
17	10	26		52·5	E		2		Do
19	9	12		40	W	0·5			Do.
19	9	5	6		W		Slight		
20	11	31	30		E	3			At top.
21	8	36		41	W	Slight			
21	8	34	45		W	Do.			
22	8	43	23		E	2			At top.
23	8	48	71		E		1		At base.
23	9	9	24		E		1·5		At top.
23	9	9	22		E	3			Do.
23	9	9	20		E	1			At base.
24	9	12	24		E		3		At top.
24	9	12	23		E	3			Do.
24	9	43	30		W	0·5			Do.
25	10	38	24		E	Slight.			
26	9	28	9		E			2	At top.
27	8	52	26		E	1			At base.
27	8	47		23	W	0·5			At top.

There was a large increase in the number of displacements, the total number observed being 420 as against 202 in the previous half-year. They were distributed as follows:—

Latitude.	North.	South.
1°—30°	134	92
31°—60°	81	43
61°—90°	47	23
Total ...	262	158

East limb	... ...	222
West limb	... ...	198
	Total ...	420

Two hundred and thirty-one displacements were towards the red, 176 towards the violet and 13 both ways simultaneously.

Reversals and displacements on the Sun's disc.

Three hundred and ninety-eight bright reversals of the Hα line, 264 dark reversals of the D_3 line and 115 displacements of the Hα line were observed on the disc during the half-year. These numbers are large increases on the previous half-year. Their distribution is shown below :—

	North.	South.	East.	West.
Bright reversals of Hα	186	212	200	198
Dark reversals of Dα	115	149	139	125
Displacements of Hα	56	59	61	54

Eighty-three displacements were towards the red, 27 towards the violet and 5 both ways simultaneously.

Prominences projected on the disc as absorption markings.

Photographs of the Sun's disc in Hα light were available from Kodaikanal and the co-operating observatories for a total of 181 days, which were counted as 180 effective days. The mean daily areas of Hα absorption markings (corrected for foreshortening) in millionths of the Sun's visible hemisphere and the mean daily numbers are given below :—

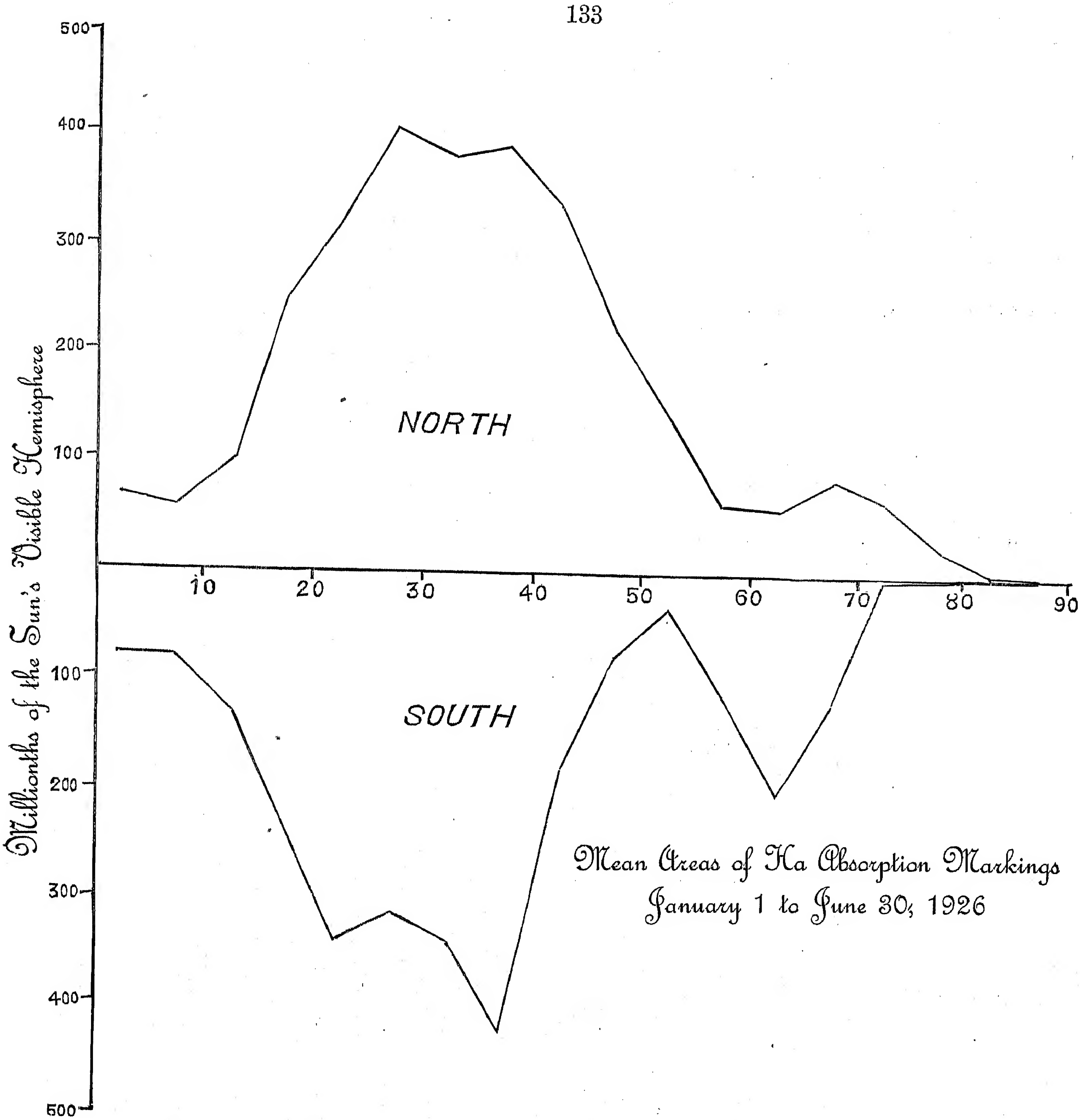
	Mean daily areas.	Mean daily numbers.
North	2946	17·2
South	2650	17·8
Total ...	5596	35·0

Areas have increased by 78 per cent and numbers by 45 per cent compared with the previous half-year.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 173 days of observation being counted as 170 effective days.

	Mean daily areas.	Mean daily numbers.
North (Kodaikanal photographs only)	3009	17·4
South do.	2700	18·2
Total ...	5709	35·6

The distribution of the mean daily areas in latitude is shown in the accompanying diagram. Compared with the previous half-year the high latitude peak has almost disappeared in the northern hemisphere but has intensified in the southern; it has advanced towards the poles by 5° in both hemispheres.



As in the case of prominences at the limb, there is a slight eastern excess of numbers and an eastern defect of areas, the percentages east being 50·28 and 47·14, respectively.

Thanks are due to the co-operating observatories for the photographs supplied by them.

THE OBSERVATORY, KODAIKANAL,
19th February 1927.

T. ROYDS,
Director, Kodaikanal and Madras Observatories.

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Kodaikanal Observatory.

BULLETIN No. LXXXI.

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE SECOND HALF OF THE YEAR 1926.

In pursuance of the programme of work adopted since 1st January 1923 under the auspices of the International Astronomical Union, all observatories taking spectroheliograms of the Sun have been asked to co-operate with the Kodaikanal Observatory by supplying copies of their photographs on those days when the Kodaikanal records are imperfect or wanting. In response to our requirements for the second half of the year 1926, the Mount Wilson Observatory supplied prominence plates for 25 days and $H\alpha$ disc plates for 19 days; Meudon Observatory supplied K_3 disc plates for 3 days and $H\alpha$ disc plates for 12 days; and the Pitch Hill Observatory (Mr. Evershed's) at Ewhurst, Surrey, England, supplied 9 prominence plates and 13 $H\alpha$ disc plates.

When only incomplete or imperfect photographs for any day are available from more than one observatory, the best photograph is chosen as representing the solar activity of that day after weighting it according to its quality, and the remaining photographs are ignored.

The mean daily areas and numbers of prominences during the half-year are given below. The means are corrected for imperfect or incomplete observations, the total of 182 days for which plates were available being reduced to 166 effective days.

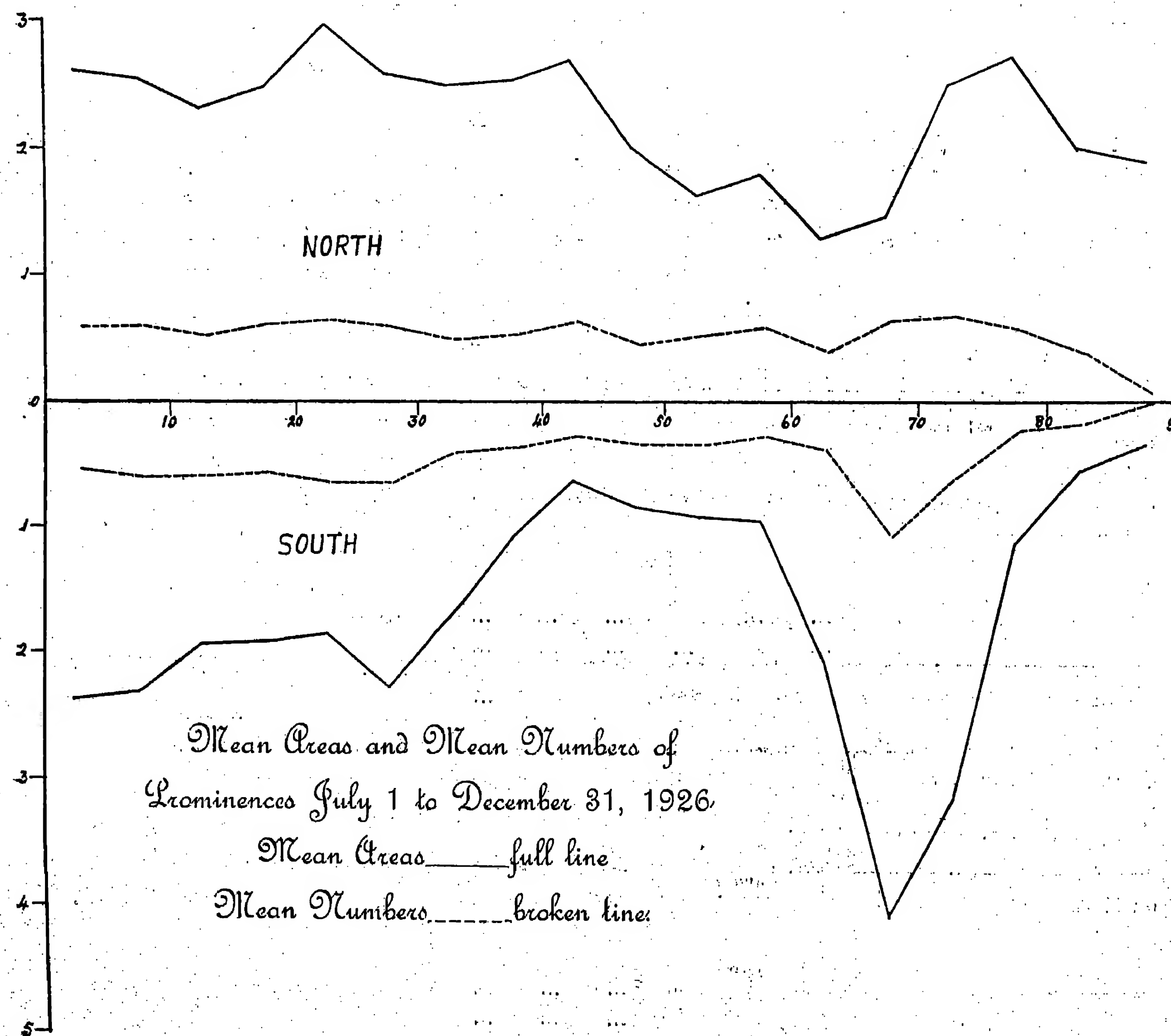
	Mean daily areas (square minutes).	Mean daily numbers.
North	4·03	9·53
South	3·02	8·32
Total ...	7·05	17·85

Compared with the previous half-year, areas show a decrease of 13 per cent both in the northern and southern hemispheres, while numbers show a slight increase in the northern hemisphere and a slight decrease in the southern, both the increase and decrease being less than 2 per cent. The excess of activity in the northern hemisphere recorded in the first half of the year has been maintained.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 155 days of observation being counted as 140 effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North (Kodaikanal photographs only)	4·40	9·72
South do.	3·26	8·56
Total ...	7·66	18·28

The distribution of the prominences in latitude is represented in the following diagram, in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude. The ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line. Compared with the previous half year the distribution exhibits some well-marked differences. The maximum in high latitudes has made a greater stride towards the poles, the advance being 10° in both the hemispheres. Although the southern hemisphere in this region still lags behind the northern by about 10°, it shows a preponderance of activity over the northern. A peak has appeared near 25° in both hemispheres, whilst the peak near 40° has disappeared in the southern hemisphere.



The monthly, quarterly and half-yearly areas and numbers, and the mean height and mean extent of the prominences on photographs from all the co-operating observatories are given in Table 1. The unit of area is 1 square minute of arc. The mean height is derived by adding together the greatest heights reached by

individual prominences and dividing by the total number of prominences observed; the mean extent is derived by adding together the lengths of the base on the chromosphere of individual prominences and dividing by the total number of prominences.

TABLE I.—ABSTRACT FOR THE SECOND HALF OF 1926.

Months.	Number of days (effective).	Areas.	Numbers.	Daily Means. Areas.	Daily Means. Numbers.	Mean height.	Mean extent.
1926.						″	°
July	28½	161·6	478	5·7	16·8	35·6	5·39
August	27¼	233·6	519	8·6	19·0	39·0	5·81
September	27¼	192·0	476	7·0	17·5	36·9	5·48
October	28½	207·5	529	7·3	18 6	40·6	5·04
November	25	172·0	424	6·9	17·0	40·1	5·71
December	29½	203·9	537	6·9	18·2	41·5	5·72
Third quarter	83	587·2	1473	7·1	17·7	37·2	5·57
Fourth quarter	83	583·4	1490	7·0	18·0	40·8	5·48
Second half-year	166	1170·6	2963	7·1	17·8	39·0	5·52

Distribution east and west of the Sun's axis.

During the half-year areas showed a large western preponderance and numbers a slight eastern preponderance, as will be seen from the following table :—

1926 July to December.	East.	West.	Percentage East.
Total number observed	1511	1452	51·0
Total areas in square minutes	524·4	646·2	44·8

Metallic prominences.

Nineteen metallic prominences were observed during the half-year, as against 133 in the previous half-year. Their details are given below :—

TABLE II.—LIST OF METALLIC PROMINENCES OBSERVED AT KODAIKANAL, JULY TO DECEMBER 1926.

Date.		Hour I.S.T.		Base.	Latitude.		Limb.	Height.	Remarks.
					North.	South.			
1926.		H.	M.	°	°	°		″	
July	16	8	53	3	19·5		E	20	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5269·8, 5276·2, 5316·8, 5535·1, D_1, D_2, 6677, 7065.
	23	8	52	1		11·5	E	25	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	30	9	18	3	20·5		W	30	b_1, b_2, b_3, b_4, D_1, D_2.
August	27	8	55	2	19		W	10	5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677.
September	1	8	53	2	32		W	30	b_1, b_2, b_3, b_4, D_1, D_2,
	4	9	0	1		11·5	W	40	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316·8, 5363·0, D_1, D_2.
	25	9	6	1	23·5		W	5	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5363·0, D_1, D_2.
	27	11	24	4	26		W	10	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 7065.
October	4	8	40	3	18·5		E	20	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
	21	9	0	1	17·5		W	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, 5363·0, D_1, D_2, 6677, 7065.
November	28	9	15	4	29		E	15	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, 5363·0, D_1, D_2.
	29	9	2	5	29·5		E	25	4924·1, 4957·8, 5016·0, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, 5363·0, D_1, D_2.
December	9	14	35			7	E	10	b_1, b_2, b_3, b_4, 6677.
	17	9	22		33		E	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, 5363·0, D_1, D_2, 6677.
	18	10	7	4	26		E	15	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, 5363·0, D_1, D_2, 6677, 7065.
	20	9	5	8		11	E	20	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, D_1, D_2, 6677.
	22	9	8		8		W	10	4924·1, 5016·0, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, D_1, D_2, 6677, 7065.
	29	8	52	2	23		W	15	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, 5363·0, D_1, D_2, 7065.
	31	12	0	4		27·5	W	20	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, D_1, D_2.

The distribution in latitude of the metallic prominences was as follows :—

	1°—10°	11°—20°	21°—30°	31°—40°	Mean latitude.	Extreme latitudes.
North ...	1	4	7	2	23°·2	8° and 33°
South ...	1	3	1	...	13°·7	7° and 27°·5

Nine were on the east limb and 10 on the west limb.

Displacements of the hydrogen line.

Particulars of the displacements observed in the chromosphere and prominences are given in the following table :—

TABLE III.—DISPLACEMENTS OF THE HYDROGEN LINE.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1926.		H.	M.	°	°		A.	A.	A.	
July	6	8	47	77·5		E	Slight			
	11	8	39	39		W	0·5			At top.
	13	11	45		21	W		Slight		
	14	9	50		55	W	1			At top.
	16	8	44		73·5	W	0·5			
	16	8	35	47		W		Slight		
	17	8	52		84	E		1		At top.
	20	8	40		6	W		Slight		
	23	8	52		12	E	Slight			
	27	8	59		24	W		Slight		
	27	8	55	70		W		Do.		
	28	9	58		14	E	2	1		To red at lower arm of bend and to violet at top of bend.
	28	9	55		17·5	E		1		At top.
	28	9	20		77	E	1			At base.
	29	9	43	20		W	0·5			At top.
	30	9	13	55		W	Slight			
August	6	11	37		19	W			1	
	8	9	0		17	W	1			At top.
	15	9	2		24	W	1·5			Do.
	15	8	58		20	W		1		Do.
	18	11	36	4		E		1		Do.
	20	9	29		35·5	E	0·5			At base.
	20	9	12	48·5		W	Slight			At top.
	22	9	1		20	W	1			Do.
	22	8	52	76		W	0·5			Do.
	23	8	21		67	W	1·5			Do.
	24	9	32	29		E	0·5			Do.
	26	10	26		32·5	W	1			
	28	9	3	59·5		E			Slight	At top.
	28	8	59	39·5		E	1·5			In chromosphere.
	28	9	29	30·5		W	Slight			At top.
	28	9	34	78		W	1			Do.
	31	9	11		13	E		1		Do.
September	1	8	41	64		W	1			Do.
	3	9	18		65	E	3			Do.
	3	9	10		24	W		Slight		Do.
	3	9	6		3	W	1			Do.
	3	9	2		36·5	W		0·5		Do.
	4	8	49		15	W	1			Do.
	4	8	49		13	W		1		At base.
	5	9	24		20	W	1			At top.
	6	10	28		57·5	W	Slight			Do.
	6	10	15	63		W	Do.			Do.
	7	9	4	15		W	1			Do.
	7	9	15	79·5		W	Slight			Do.
	13	9	46	25		E		1		Do.
	17	9	17		41	E	1			At base.
	17	9	10	27		W	Slight			At top.
	24	9	24		18	E	0·5			At base.
	24	9	6	44·5		W		1		Do.
	24	9	5	71·5		W		Slight		
	25	9	27	Equat	or.	W	0·5			At top.
	25	9	6	23·5		W		Slight		At base.
	25	8	59	58·5		W			Slight	At top.
	27	10	26	23		E	0·5			Do.
	27	10	15	15		W	1			Do.
	27	9	32	19		W	2			At base.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1926.		H.	M.	°	°		A.	A.	A.	
September	27	9	30	26		W	1			At top.
	29	9	5	9		W	0·5			Do.
October	2	9	33		23	W	Slight			Do.
	3	8	54	15·5		E	1			At base.
	3	8	56		8	E	0·5			Do.
	3	8	46		24	W		Slight		
	4	8	40	18·5		E	1	1		To violet at top; to red at base. D_1, D_2, D_3, also were displaced.
	4	9	2		68	E	1·5			At top.
	4	9	12		73·5	E		0·5		Do.
	4	8	27	61		W		0·5		At base.
	5	9	15	73		E	1			At top.
	5	9	27	17		E	2	1		To red at base; to violet at top. Seen in D_3 also.
	5	9	48		2·5	E		3		At top.
	5	10	7		65	E	1			At top.
	5	8	54		65	E		0·5		Do.
	5	10	6		67	E		1·5		Do.
	6	8	47	20		E	0·5			
	6	8	50	16		E		1		At top.
	6	9	4	16		E	1			
	9	9	22	27		E		0·5		
	9	8	55	23		E		1		At top.
	9	9	21	23		E	0·5			At base.
	9	8	50		16	W	0·5			At top.
	11	8	18	26		E	0·5			Do.
	13	9	11	25		W		0·5		
	14	8	50	84		E		Slight		
	14	8	52	58·5		W	1			At top.
	15	8	10	11		W	1			Do.
	15	8	54	41·5		W	1			Do.
	19	9	4	18		W	0·5			Do.
	19	9	19	32		W		1		At base.
	19	8	51	43		W		3		Do.
	21	9	10	39·5		E	1			At top.
	21	9	0	17·5		W	0·5	1·5		To red at top; to violet at base.
	21	8	57	26		W	0·5			At top.
	21	8	57	30		W		0·5		At base.
	21	8	52	62·5		W		Slight		Do.
	22	9	7		13	E	1			Do.
	22	9	11		34	E	0·5			Do.
	22	8	50	27·5		W	1			At top.
	22	8	44	82·5		W	0·5			Do.
	23	8	45		12	E	1·5			At base.
	23	8	45		14	E		4·5		At top.
	23	8	50		14	E	1			At base.
	23	8	24	21		W		0·5		Do.
	23	8	17	50·5		W		0·5		Do.
	23	8	15	69·5		W	Slight			
	24	9	0	19		E		0·5		At top.
	24	9	0	18		E	1			At base.
	24	8	54	33		W	0·5			At top.
	27	9	20		16	E		0·5		Do.
	30	8	58	24		E	1			At base.
November	3	9	12	49		E	Slight			Do.
	4	10	8	32		E	1			Do.
	8	15	20		18	E	1			At top.
	9	9	24		25	E	0·5			Do.
	9	8	51	13		W		0·5		At base.
	10	9	27	27		E	1			Do.
	10	9	22		29	E		1·5		At top.
	10	9	22		31	E	1			At base.
	10	9	16	21		W		1		Do.
	12	8	55		5	W	Slight			

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1926.		H.	M.	°	°		A.	A.	A.	
November	13	9	27	13		W	1			At top.
	14	8	36	24		W	Slight			Do.
	15	9	48	23		E		1		Do.
	15	9	15		16	E	1			At base.
	15	8	40	10		W	2·5			At top.
	15	8	40	15		W		1		At base.
	15	8	40	19		W	5	2		To red at top; to violet at base.
	15	9	40	19		W	6			At top.
	15	8	40	23		W	3			Do.
	15	11	20	25		W	3	2		To red at top; to violet at base.
	16	8	55	19		W	1			At top.
	16	8	48	28		W	0·5	1		To red at top; to violet at base.
	17	9	15		60·5	E	0·5			
	17	9	2	15		W	1			At top.
	17	8	48	30		W	1			Do.
	17	8	47	37		W		Slight		At base.
	19	8	20	30		W		0·5		Do.
	25	10	22		47	E		3		Over whole prominence.
	26	10	8	6		W	2			At top.
	28	9	15	14		E	1			Do.
	28	9	15	1		E		2		Do.
	28	8	58	65		W	Slight			Do.
	29	9	2	30		E	1			At base.
	29	10	1	12		E	1·5			Do.
	29	9	25		12	W	1			At top.
	30	9	9	43		E	1			Do.
	30	9	12	32		E			1·5	
	30	9	14	12		E		1		
	30	9	3		19	W	0·5			At base.
	30	8	58	16		W	0·5			At top.
December	1	9	21	42		E	Slight			At base.
	1	9	15	7·5		W		0·5		Do.
	1	9	3	53		W	Slight			At top.
	2	11	3	89·0		E		Slight		
	2	11	34		25	E	1	2		To red at base; to violet at top.
	3	10	45		32	E		0·5		At top.
	3	10	45		35	E	1			Do.
	3	9	30	5		W	0·5			
	3	10	52	24		W	0·5			At top.
	4	9	3	14·5		E	1·5			At base.
	4	9	35	79		W	0·5			Do.
	5	9	10		11	W	4	1		At top.
	6	8	35	62		E	Slight			
	6	8	36	8		E	0·5			
	6	8	25		22	W		1		At base.
	6	8	25		16	W	2			At top.
	6	8	21	31		W	0·5			Do.
	7	8	47	14		E	0·5			
	7	8	49		18	E		1		
	7	8	49		20	E	1·5			At base.
	7	8	50		25	E	Slight			Do.
	7	8	34		39	W		Slight		
	7	8	30		33	W	0·5			
	7	8	20	60		W	0·5			
	9	14	35		7	E		1		
	10	9	30		22	W	0·5			At base.
	11	10	25	36		W		Slight		Do.
	12	9	16		25	E	1			Do.
	12	9	16		30	E		2		At top.
	12	9	0		43	W		Slight		
	12	8	55		20	W		1		At top.
	12	8	47	9		W	1			Do.
	13	8	35	71		E		0·5		At base.
	13	8	44		28	E			1	
	13	8	42	40		W		1		At top.
	13	8	38	57		W	Slight			Do.

Date.	Hour I.S.T.	Latitude.		Limb.	Displacement.			Remarks.
		North.	South.		Red.	Violet.	Both ways.	
1926.	H. M.	°	°		A.	A.	A.	
December 14	9 2	16		W	1			At top.
17	9 8	50		E	1			
17	9 22	33		E	1			At top.
17	9 22	30		E	1			At base.
18	10 7	26		E	1	1·5		To red at base ; to violet at top.
19	9 20	17		E	0·5			At base.
19	9 24		14	W	1			At top.
20	9 5		8	E	1·5			Do.
20	9 5		14	E	1			Do.
20	8 40	67		W	Slight			Do.
21	8 58	74		E	0·5			Do.
21	9 4	80		W		0·5		At base.
22	9 10		19	E	2			At top.
22	9 24		16	W	1			Do.
22	9 8	8		W	1·5	1		To red at top ; to violet at base.
23	10 9	68		E		Slight		
23	10 15		20	W			1	
24	9 14		2·5	W	0·5			
24	9 10	63		W	1			At top.
25	9 30	16		E		0 5		At base.
25	9 23	12·5		W		5		Do.
26	9 20	25		E	1			Do.
26	8 57		7	E	0·5			Do.
26	9 8		48	W		1		
26	9 4		11	W	0·5			At top.
26	9 0	18		W	1			Do.
27	10 40	11		E	0·5			At base.
28	9 4	10		E	1			Do.
28	9 25	10		E		1		At top.
29	9 10		23	E		Slight		
29	8 54	17		W		1		At top.
29	8 52	23		W	2	3		To red at base ; to violet at top
29	8 44	78·5		E	Slight			At top.
31	12 0		24	W	1			Do.

The total number of displacements was 230 as against 420 in the previous half-year, and they were distributed as follows :—

Latitude.	North.	South.
1°—30°	87	62
31°—60°	30	15
61°—90°	25	11
Total ...	142	88

East limb	103
West limb	127
Total ...	230

One hundred and forty-three displacements were towards the red, 81 towards the violet and 6 both ways simultaneously.

Reversals and displacements on the Sun's disc.

Three hundred and seven bright reversals of Hα line, 192 dark reversals of D_3 line and 102 displacements of Hα line were observed during the half-year. Their distribution is given below :—

	North.	South.	East.	West.
Bright reversals of Hα	159	148	153	154
Dark reversals of D_3	97	95	102	90
Displacements of Hα	63	39	49	53

Seventy-six displacements were towards the red, 23 towards the violet and 3 both ways simultaneously.

The Eruptive Prominence of 10th December 1926.

A noteworthy eruptive prominence was photographed on 10th December 1926 and appeared in the first photograph taken at 8^h 0^m I.S.T. as a tall thin column, $5\frac{1}{2}'$ high, standing on a cone-shaped base extending from $-67°$ W to $-77°$ W. Its height increased and at 9^h 13^m the upper portion became detached and continued to ascend. This "flying column" had a length of $5\frac{1}{4}'$ and although the top extended beyond the limits of the photograph in later cases, the bottom ultimately reached a height of 14′ above the chromosphere. The velocity of ascent did not exceed 54 kilometers per second. The propelling force appeared to have its origin at the more northerly end of the base of the prominence.

Prominences projected on the disc as absorption markings.

Photographs of the Sun's disc in Hα light were available from Kodaikanal and the co-operating observatories for a total of 180 days, which were counted as 173 effective days. The mean daily areas of Hα absorption markings (corrected for foreshortening) in millionths of the Sun's visible hemisphere and the mean daily numbers are given below :—

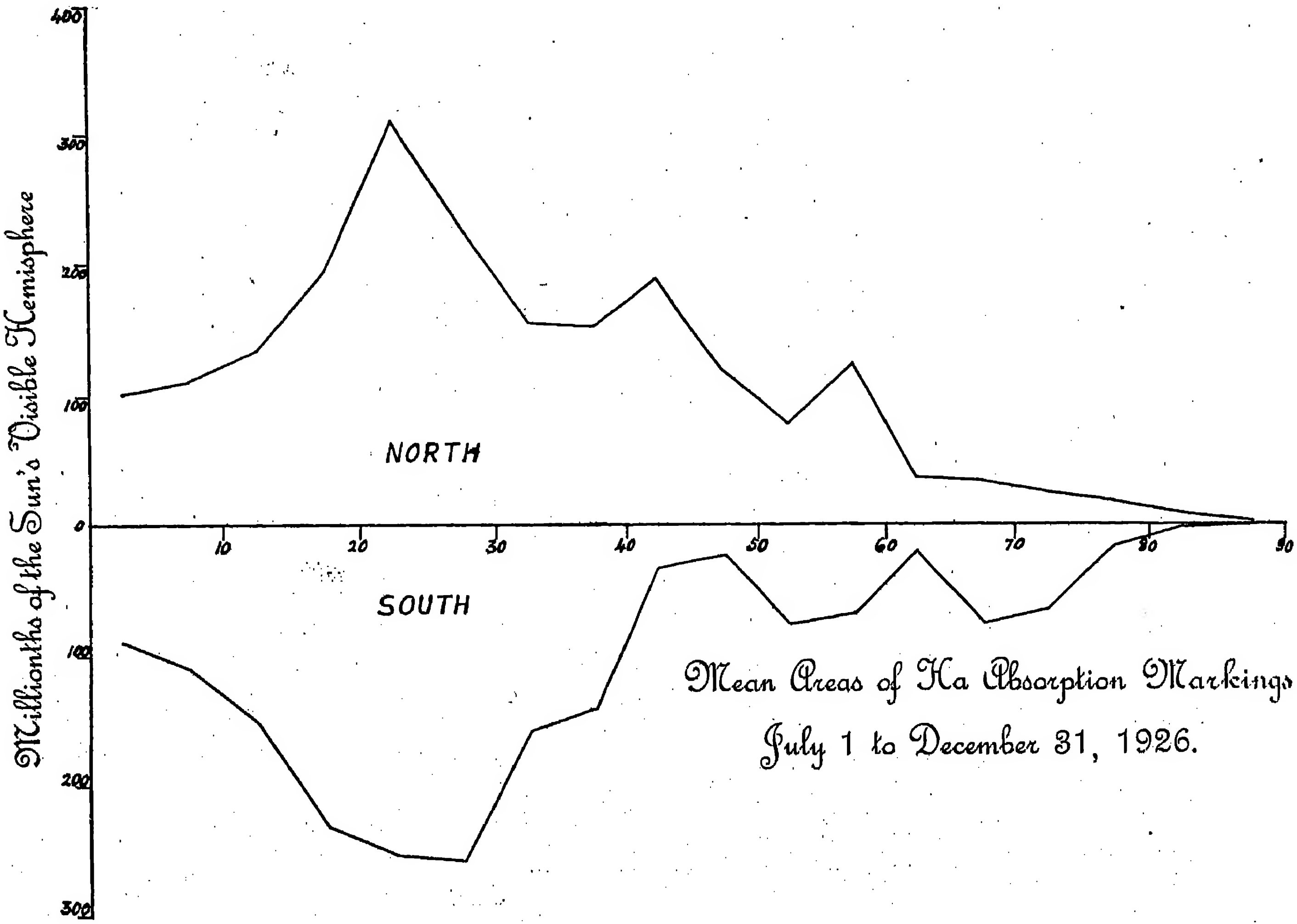
	Mean daily areas.	Mean daily numbers.
North	2,094	17·3
South	1,724	15·5
Total ...	3,748	32·8

There is a decrease of 33 per cent in areas and of 6 per cent in numbers, compared with the previous half-year.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 153 days of observation being counted as 149 effective days.

	Mean daily areas.	Mean daily numbers.
North (Kodaikanal photographs only)	2,051	17·4
South do.	1,707	15·3
Total ...	3,758	32·7

The distribution of the mean daily areas in latitude is shown in the following diagram. The main feature of the latitude distribution of Hα dark markings is a maximum near 25°, the activity in both polar and equatorial regions being relatively small compared with prominence activity.



The activity was in excess in the western hemisphere, the percentage east being 48·93 for numbers and 46·60 for areas.

Thanks are due to the co-operating observatories for the photographs supplied by them.

THE OBSERVATORY, KODAIKANAL,
23rd August 1927.

T. ROYDS,
Director, Kodaikanal and Madras Observatories.

PRICE, 8 *annas.*

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Kodaikanal Observatory.

BULLETIN No. LXXXII.

A BRILLIANT DAYLIGHT COMET OBSERVED AT KODAIKANAL.

By P. R. CHIDAMBARA AYYAR, B.A., F.R.A.S.

A brilliant comet visible by daylight was seen at Kodaikanal on the 15th December 1927 and it now appears likely that it is De Vico's long-period comet 1846 IV, first observed by Mr. J. F. Skjellerup at Melbourne on December 3, 1927, at 17h. 30m. U.T. in R.A. 16h. 12m. 12s., S Decln. 53° 57′ (vide *Nature*, 10th December 1927, page 854, Astr. Column). At the time of preparation of this bulletin, it was not known that any previous observation of the comet had been made.

The Director having left for Madras on the 14th December 1927, I was taking spectroheliograms of the sun on the morning of 15th December, when, at about 8-30 a.m., I.S.T., the peon Poomban, whose duty it was to wind the clock of the siderostat mirror and report the advance of clouds, informed me that there was something bright quite near the sun. As there were small patches of fleecy clouds near the sun, I at first thought that this was also one such, but immediately it became quite evident to me that it was a very bright comet. There was the bright head and there was the tail directed away from the sun. The head was clearly brighter than Venus seen some distance ahead in the west. The other Assistants were at once informed by telephone of the apparition and they and all the other members of the staff saw it. At 8-35 a.m. I made a drawing of the object as it was visible to the naked eye at that time. The head of the comet was about three apparent solar diameters away from the centre of the sun to the east and a little to the south. The tail was not long but at the broadest part was nearly equal to a quarter of the sun's visible disc. Plate I, figure 1, represents its appearance at 8-35 a.m.

At about 9 a.m. an express telegram was despatched to the Madras Observatory with the request to verify the apparition. This message, it was afterwards learnt, was never delivered to the addressee, as a result of which a series of valuable observations of the comet have been missed.

As the object was very close to the sun it was not possible to see it in any of the telescopes, the sun's glare flooding the instruments. There were already some changes taking place in the appearance of the comet. At 12-10 p.m., therefore, I made another drawing of it as seen by the naked eye. This is Plate I, figure 2. It will be seen that the tail at the upper portion was much longer than in the morning, although the noonday sun was shining very close to the comet. At about 2 p.m. a cablegram was despatched to the Astronomer Royal, Greenwich Observatory, informing him of the appearance of the comet near the sun and giving its approximate position. By 2-30 p.m. clouds began to gather, which made further observations impossible on that day.

Plate I, figure 3, represents the appearance of the comet to the unaided eye on the morning of December 16, 1927, at 7-35 a.m. It had by then receded to a distance of nearly 4½ diameters from the sun's centre, had passed to the north and had become less bright than on the previous day. In the three-inch telescope, at 10 a.m., it had the appearance represented in Plate I, figure 5 and an hour later, in the finder of the photoheliograph—also a three-inch telescope—that represented in Plate I, figure 6. The clear-cut nucleus was dazzling gold and there were two arms of almost the same colour but less bright emanating from it on either side, one more curved than

the other, and the whole thing was wrapped up in a nebulous head and a bifurcated tail which were the colour of bright polished copper. There was only one difference between the appearances an hour apart, namely, that at 11 a.m. one section of the tail had become longer. At 3-0 p.m. when looked at in the three-inch telescope, the appearance was as shown in Plate I, figure 7. The tail had become enormous, symmetry had already begun to be established between the two sections and there were signs of the tail losing its bifurcation and becoming one combined stream.

On the morning of the 17th December the naked-eye appearance was as shown in Plate I, figure 4. When examined in the finder of the photoheliograph, it was found that the changes which were noticed to be taking place the previous afternoon had become complete. There were only the bright clearly defined nucleus and an undivided tail, the longitudinal gap in the middle of the latter having completely filled up. I mounted on the photoheliograph a Wellington and Ward 10″ × 10″ Lantern Plate and started the exposure at 11-20 a.m. keeping the comet in position by looking through the finder and ceaselessly guiding it by the slow-motion arrangements. There was an interruption by clouds from 11-25 to 11-30. I continued the exposure till 12-25 p.m., so that allowing for the interruption by clouds the plate was exposed for exactly one hour. On development the plate was found to be deeply fogged by the diffused daylight, but there was a very faint reversed (i.e., positive) image of the comet on it. The image has been intensified by being transferred a number of times from plate to plate, but unfortunately it is found to be duplicated on account of error in guiding during the long exposure.

On the 18th the comet was not visible to the naked eye and had to be picked up in the telescope. There was no change in appearance worth mentioning, except that it had become smaller and fainter.

On the 16th, 17th and 18th its positions were noted once a day and they are given below :—

Date	Time I.S.T.		Right Ascension.		Declination.
1927.	h.	m.	h.	m.	
16th December	12	0	17	37	20° 7′ S
17th „	10	10	17	43	17° 20′ S
18th „	11	14	17	46	14° 43′ S

The sky was cloudy on the 19th and no further observations were attempted.

KODAIKANAL,
7th January 1928.

P. R. CHIDAMBARA AYYAR,
Assistant, Solar Physics Observatory, Kodaikanal.

DIRECTOR'S NOTE.

The first intimation received by me was Mr. P. R. Chidambara Ayyar's letter, received in Madras on the morning of the 18th December. I looked for the comet in the neighbourhood of the sun but failed to see it with the naked eye. The sky was hazy round the sun. The same evening the sunset was observed but no comet was seen either before or after sunset. At sunrise next morning the eastern sky was cloudy near the horizon and no comet was seen. In view of the uncertainty of its position it did not seem worth while attempting telescopic observations, so no confirmation of Mr. Chidambara Ayyar's observation was obtained in Madras. It is a pity that Mr. Chidambara Ayyar's first telegram was not received in Madras.

KODAIKANAL,
7th January 1928.

T. ROYDS,
Director, Kodaikanal and Madras Observatories.

PRICE, 5 *annas* 6 *pies*. MADRAS : PRINTED BY THE SUPERINTENDENT, GOVERNMENT PRESS—1928.

Plate I

Brilliant Daylight Comet Observed at Kodaikanal

Naked-eye View

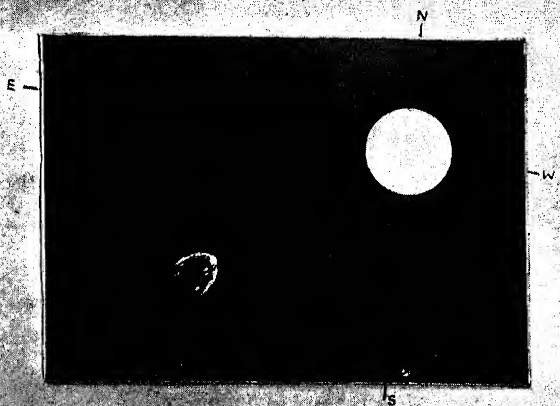


Fig. 1. 8-35 A.M., I.S.T., 15th Dec. 1927.

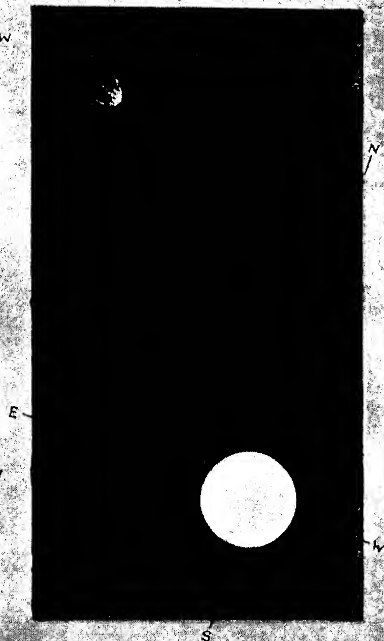


Fig. 3. 7-35 A.M., I.S.T., 16th Dec. 1927.

Fig. 4
8-40 A.M., I.S.T., 17th Dec. 1927.

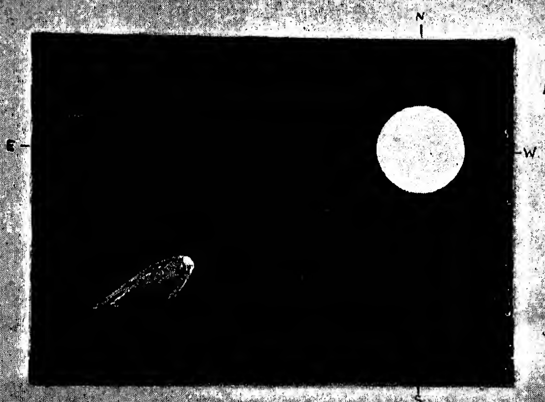


Fig. 2. 12-10 P.M., I.S.T., 15th Dec. 1927

Telescopic View

Fig. 5
10-0 A.M., I.S.T., 16th Dec. 1927. In 3-inch Telescope.

Fig. 6.
11-0 A.M., I.S.T., 16th Dec. 1927. In Photoheliograph Finder

Fig. 7. 3-0 P.M., I.S.T., 16th Dec. 1927. In 3-inch Telescope.

Kodaikanal Observatory.

BULLETIN No. LXXXIII.

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE FIRST HALF OF THE YEAR 1927.

In pursuance of the programme of work adopted since 1st January 1923 under the auspices of the International Astronomical Union, all observatories taking spectroheliograms of the sun have been asked to co-operate with the Kodaikanal Observatory by supplying copies of their photographs on those days when the Kodaikanal records are imperfect or wanting. In response to our requirements for the first half of the year 1927, the Mount Wilson Observatory supplied prominence plates for 21 days and Hα disc plates for 18 days; Meudon Observatory supplied K_3 disc plates for 18 days and Hα disc plates for 12 days; and the Pitch Hill Observatory (Mr. Evershed's) at Ewhurst, Surrey, England, supplied 1 prominence plate and 1 Hα disc plate.

When only incomplete or imperfect photographs for any day are available from more than one observatory, the best photograph is chosen as representing the solar activity of that day after weighting it according to its quality, and the remaining photographs are ignored.

The mean daily areas and numbers of prominences during the half-year are given below. The means are corrected for incomplete or imperfect observations, the total of 178 days for which plates were available being reduced to 164½ effective days.

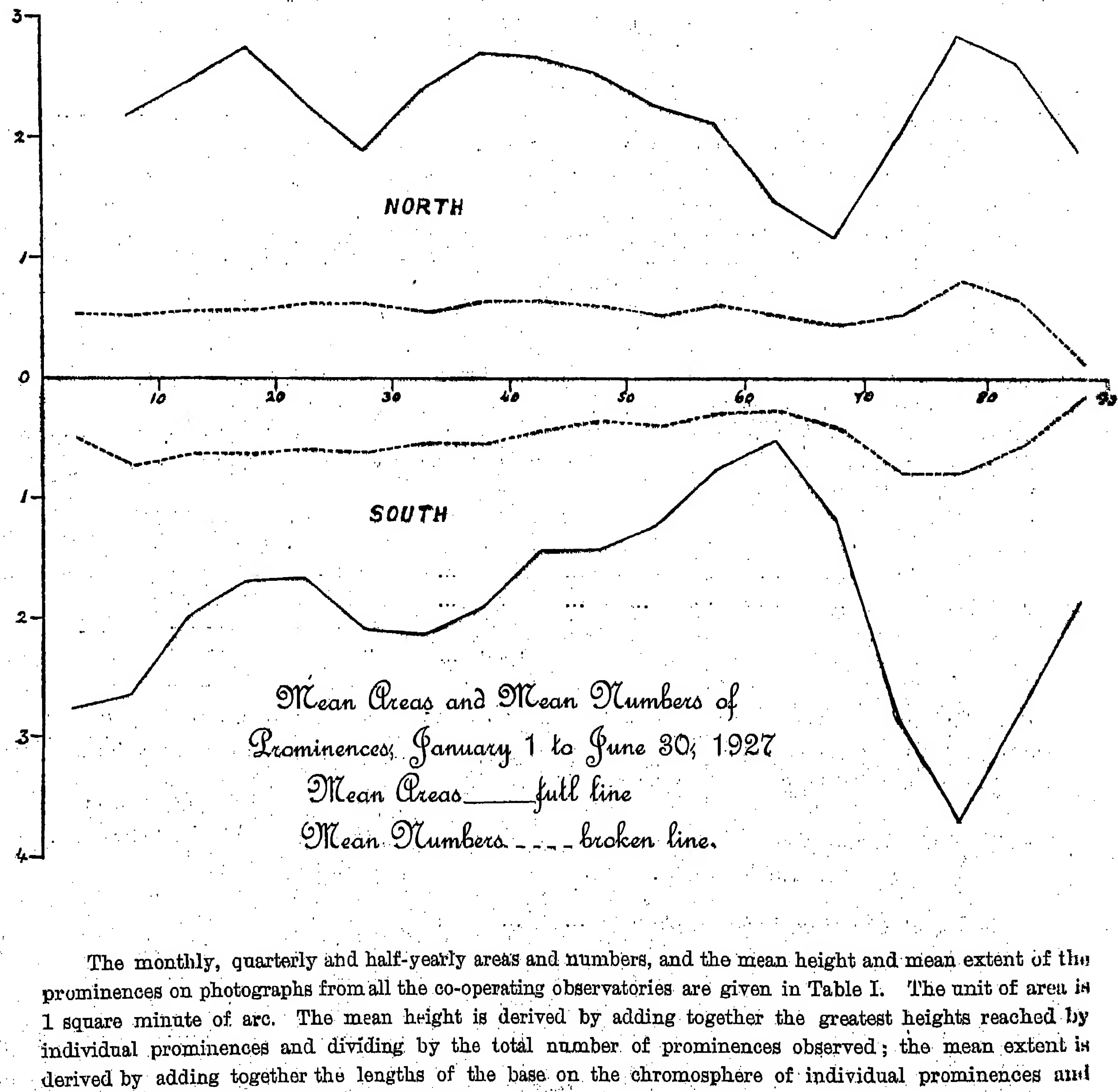
	Mean daily areas (square minutes).	Mean daily numbers.
North	4·04	10·01
South	3·46	9·34
Total ...	7·50	19·35

Compared with the previous half-year, areas remain the same in the northern hemisphere, although numbers are 5 per cent larger, but in the southern hemisphere both areas and numbers show an increase, namely, 15 per cent and 12 per cent, respectively.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 158 days of observation being counted as 148½ effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North (Kodaikanal photographs only)	4·15	10·01
South do.	3·58	9·36
Total ...	7·73	19·37

The distribution of the prominences in latitude is represented in the following diagram, in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude. The ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line. The high latitude maximum has remained stationary in the northern hemisphere and advanced about 5° towards the pole in the southern when compared with the previous half-year. The minimum of activity near 65° has become more marked than in the previous half-year.



Mean Areas and Mean Numbers of Prominences, January 1 to June 30, 1927
Mean Areas _____ full line
Mean Numbers - - - - broken line.

The monthly, quarterly and half-yearly areas and numbers, and the mean height and mean extent of the prominences on photographs from all the co-operating observatories are given in Table I. The unit of area is 1 square minute of arc. The mean height is derived by adding together the greatest heights reached by individual prominences and dividing by the total number of prominences observed; the mean extent is derived by adding together the lengths of the base on the chromosphere of individual prominences and dividing by the total number of prominences.

TABLE I.—ABSTRACT FOR THE FIRST HALF OF 1927.

Months.	Number of days (effective).	Areas.	Numbers.	Daily Means.		Mean height.	Mean extent.
				Areas.	Numbers.		
1927.						″	°
January	28¾	232·5	557	8·1	19·4	41·7	6·11
February	26¾	186·9	483	7·0	18·1	41·3	6·61
March	27½	220·2	497	8·0	18·1	42·2	6·51
April	29	213·3	564	7·4	19·4	35·0	6·12
May	28¼	210·6	561	7·5	19·9	40·4	6·02
June	24¼	169·1	527	7·0	21·7	37·1	5·31
First quarter	83	639·6	1537	7·7	18·5	41·7	6 40
Second quarter	81½	593·0	1652	7·3	20·3	37·5	5·83
First half-year	164½	1232·6	3189	7·5	19·4	39·5	6·10

Distribution east and west of the Sun's axis.

During the half-year areas showed a slight western excess and numbers a slight eastern excess as will be seen from the following table :—

1927 January to June.	East.	West.	Percentage East.
Total number observed	1605	1584	50·3
Total areas in square minutes	601·0	631·7	48·8

Metallic prominences.

Sixty-three metallic prominences were observed during the half-year, as against 19 in the previous half-year. Their details are given below :—

TABLE II.—LIST OF METALLIC PROMINENCES OBSERVED AT KODAIKANAL, JANUARY TO JUNE 1927.

Date.		Hour I.S.T.		Base.	Latitude.		Limb.	Height.	Lines.
					North.	South.			
1927.		H.	M.	°	°	°		″	
January	1	8	55		23		W	15	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677.
	2	9	2			14	E	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, 6677, 7065.
	2	9	6	4		28	W	30	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, D_1, D_2.
	4	10	5	3		15·5	E	15	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	8	9	21	6		10	W	20	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, D_1, D_2, 6677.
	10	9	22	2	6		W	25	4924·1, 5016, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, 5363·0, D_1, D_2.
	15	12	26	5		17·5	W	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2. 6677.
	17	9	25	4		16	W	20	4924·1, 5016·8, b_1, b_2, b_3, b_4, 5276·2, 5316·8, D_1, D_2, 6677.
	18	8	58	3	8·5		W	15	b_1, b_2, b_3, b_4, D_1, D_2, 6677.
	21	10	35		17		W	30	4924·1, b_1, b_2, b_3, b_4, D_1, D_2.
	25	9	18	6		26	W	15	4924·1, 5016·0, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, 5363·0, D_1, D_2.
	26	11	32	3	20·5		W	10	b_1, b_2, b_3, D_1, D_2.
	29	9	53			17·5	E	10	D_1, D_2, 6677, 7065.
February	1	9	2	4	26		E	15	5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
	2	9	2	3	13·5		E	15	4924·1, 5016·0, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, D_1, D_2, 6677, 7065.
	3	10	35			13	E	10	4924·1, 5016.0, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, 5363·0, D_1, D_2, 6677, 7065.
	4	10	16	4		14	W	20	4924·1, 5016·0, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, D_1, D_2, 7065.
	5	8	54		33		E	10	4924·1, 5016·0, 5018·6, b_1, b_2, b_3, b_4, 5270·0, 5276·2, 5316·8, D_1, D_2.
	8	9	39	6		27	E	20	4924·1, 5016·0, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, 5363·0, D_1, D_2, 6677, 7065.
	15	9	6	3	8·5		W	10	4924·1, 5016·0, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, 5363·0, D_1, D_2, 6677, 7065.
	15	8	42	4	16		W	20	4924·1, 5016·0, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, 5363·0, D_1, D_2,
	16	8	55	3		13·5	W	15	4924·1, 5016·0, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, D_1, 5363 0, D_2.
	20	8	39	3	23·5		E	15	4924·1, 5016·0, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, 5363·0, D_1, D_2.
	22	9	5	3	31·5		E	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	23	8	40	3	16·5		E	20	4924·1, 5016·0, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, 5363·0, D_1, D_2.
	23	8	50		27		W	20	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, D_1, D_2, 6677, 7065.
	27	9	15	4		4	E	10	4924·1, 5016·0, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, D_1, D_2, 7065.
	27	9	28	3		21·5	E	30	4924·1, 5016·0, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, 5363·0, D_1, D_2.
	28	9	20	2	20		E	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
March	5	9	12	7		26·5	W	20	4924·1, 5016·0, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, D_1, D_2, 6677, 7065.
	6	9	8	2		25	W	10	4924·1, 5016·0, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677.
	9	8	26	2		20	W	15	4924·1, 5016·0 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, 5363·0, D_1, D_2, 6677, 7065.
	12	9	48	2	23		E	10	b_1, b_2, b_3, b_4, D_1, D_2.
	13	9	8	4	32		E	10	4924·1, 5016·0, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, 5363·0, D_1, D_2, 6677, 7065.

Date.		Hour I.S.T.		Base.	Latitude.		Limb.	Height.	Lines.
					North.	South.			
1927.		H.	M.	°	°	°		"	
March	14	9	14	11	35·5		E	20	4922 4, 4924·1, 5016 0, 5018 6, b_1, b_2, b_3, b_4, 5276·2, 5316 8, 5363·0, D_1, D_2, 6677, 7065.
	15	9	53	3		10·5	W	10	b_1, b_2, b_2, b_4, 5316 8, D_1, D_2.
	19	10	20	1	15·5		W	5	b_1, b_2, b_3, b_4, D_1, D_2.
	24	9	23	2	42·5		W	20	4924·1, 5016 0, 5018·6 b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	27	9	5	3	16 5		W	20	4924·1, 5016·0 5018 6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, 5363·0, D_1, D_2, 6677.
	27	9	0	4	28		W	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
	28	8	46	4	15		W	15	5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	31	9	25	1	12·5		E	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5269·8, 5276·2, 5363·0, D_1, D_2, 6677, 7065.
April	5	9	30	3		11·5	E	10	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
	6	9	47	9		15·5	E	15	4922 0, 4924·1, b_1, b_2, b_3, b_4, 5198·0, 5206·3, 5208·7, 5234·8, 5276 2, 5316·8, 5363·0, D_1 D_2, 6677, 7065.
	6	10	57	2		22	W	20	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5234·8, 5276·2, 5316 8, 5363 0, D_1, D_2, 6677, 7065.
	7	10	46	5	41·5		E	15	b_1, b_2, b_3, b_4, D_1, D_2.
	8	8	55	5	19·5		E	20	b_1, b_2, b_3, b_4, D_1, D_2, 6677.
	8	8	31	4		16	W	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065
	10	9	12	3	29·5		E	10	b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 7065.
	11	8	45	6	37		E	10	b_1, b_2, b_3, b_4. 5316 8, D_1, D_2, 6677, 7065.
	11	8	26			12	E	10	4924·1, 5016·0, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2, 6677, 7065.
	12	8	45	2	26		E	10	b_1, b_2, b_3, b_4, D_1, D_2.
	12	8	33	6	3		W	10	4924 1, 5016·0, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, 5363·0, D_1, D_2, 6677, 7065.
	13	10	14			17	E	10	b_1, b_2, b_3, b_4, D_1, D_2.
	13	10	50	1	13·5		W	15	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, 5363·0, D_1, D_2, 6677, 7065.
	20	10	0	1		21·5	E	10	b_1, b_2, b_3, b_4, 5316 8, D_1, D_2; 7065.
	24	8	45	10		13	W	15	4924·1, 5016·0, 5018·6, b_1, b_2, b_3, b_4, 5270·0, 5276·2, 5316·8, 5363·0, D_1, D_2, 6677, 7065.
May	7	9	33	4		4	E	20	4924·1, 5016·0, 5018 6, b_1, b_2, b_3, b_4, 5270·0, 5276·2, 5316·8, 5363·0. D_1, D_2.
	7	9	36	2		10	E	10	5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, D_1, D_2.
	8	10	0	4		12	E	15	5018·6, b_1, b_2, b_3, b_4, 5316 8, D_1, D_2.
	14	10	5	3		13·5	W	10	b_1, b_2, b_3, b_4, 5316·8, 6677.
	22	9	15	3		20·5	E	10	4924·1, 5018·6, b_1, b_2, b_3, b_4, 5316·8, D_1, D_2.
	25	9	55			26	W	10	5018·6, b_1, b_2, b_3, b_4, 5276·2, 5316·8, D_1, D_2, 6677, 7065.

The distribution in latitude of the metallic prominences was as follows :—

	1°—10°	11°—20°	21°—30°	31°—40°	41°—50°	Mean latitude.	Extreme latitudes.
North ...	4	11	9	5	2	22° 0	3° and 42°·5
South ...	4	18	10	...	...	16°·7	4° and 28°

Thirty-two were on the east limb and 31 on the west limb.

Displacements of the hydrogen lines.

Particulars of the displacements observed in the chromosphere and prominences are given in the following table :—

TABLE III.—DISPLACEMENTS OF THE HYDROGEN LINES.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1927.		H.	M.	°	°		A.	A.	A.	
January	1	8	51	81·5		E		Slight		At base.
	1	9	3		13	E		1·0		At top.
	1	8	55	23		W	2	1·0		To red at top ; to violet at base.
	2	9	24	13		E		1·0		At base.
	2	9	2		11	E	1·5			At top.
	2	9	2		14	E		1·0		At base.
	2	9	6		20	W	1·0			At top.
	2	9	14	44		W		1·0		At base.
	3	10	28	40		W		1·0		
	4	9	33	59		E		0·5		At base.
	4	9	59	4		E		1·0		At top.
	4	10	5		15	E		1·5		Do.
	4	10	5		17	E	1·0			At base.
	4	9	44		12	W		Slight		Do.
	8	9	5	44		E	1·0			At top.
	8	9	3	30		E	Slight			Do.
	8	9	28	11		E	0·5			At base.
	8	9	41		45	E		0·5		At top.
	8	9	30		42	W	Slight			Do.
	8	9	21		8	W	1·5			Do.
	8	9	14	23		W	1·5			Do.
	8	9	12	42		W	1·0			Do.
	9	9	1	39		E	0·5			Do.
	9	9	25		13	E	1·0			At base.
	10	9	7		40	W	0·5			At top.
	10	9	22	8		W	1·0			Do.
	11	9	23	10		E	1·0			At base.
	11	9	22	53		E	Slight			No prominence.
	11	9	32		83·5	E	Do.			At base.
	11	9	12		22	W	1·0	0·5		To red at top ; to violet at base.
	11	9	2	16		W	Slight			
	11	8	55	74·5		W	0·5			At top.
	13	11	51	34		E		2·0		Do.
	13	11	54	28		E	1·5	2·5		
	13	10	40	24		W		1·0		At base.
	15	12	26		18	W	0·5			At top.
	16	8	43		13	E	2·0	1·0		To red at base ; to violet at top.
	16	8	16		16	W	7·0			At top ; in the middle of the prominence C was displaced 1·5 A to red.
	16	8	16		13	W		1·0		At base.
	17	9	31	68·5		E	Slight			Do.
	17	9	6	64·5		E	Do.			At top.
	17	9	4	51·5		E	0·5			At base.
	17	9	34	40		E	1·0			At top.
	17	9	0	24		E	0·5			
	17	10	2		18	W		2·0		At base.
	17	9	25		16	W	2·5	1·0		To red at top ; to violet at base. A ghost of C was displaced 6·0 to red at top.
	17	9	12	43		W		Slight		No prominence.
	18	8	46	47		E	Slight			At base.
	18	9	3	14		E		Slight		At top.
	18	9	0		17	W	1·0	0·5		To red at top ; to violet at base.
	18	8	58	10		W	0·5			At top.
	19	8	55	58·5		E	Slight			At base.
	19	9	18	21		E		1·5		At top.
	19	8	50	18		E	1·5			Do.
	19	9	5		24	W	1·0			Do.
	19	9	3		17	W	1·5			Do.
	20	10	46	84		E		Slight		At base.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1927.		H.	M.	°	°		A.	A.	A.	
January	20	10	41	18		E		0·5		At top.
	23	10	33	10		E		1·0		Do.
	24	9	13		24	W	1·0			Do.
	24	9	7	18		W	1·0			Do.
	24	8	51	63·5		W	0·5			Do.
	24	8	50	78·5		W	1·0			Do.
	25	8	44	42		E		0·5		Do.
	25	10	32	24		E		0·5		Do.
	25	8	54	7		E	0·5			Do.
	25	9	16		37	W		2·0		Do.
	25	9	18		28	W	2·0	4·0		To red at base ; to violet at top.
	25	8	49	20		W		0·5		At base.
	25	8	47	26		W		1·5		In the middle of prominence.
	25	8	46	75		W		Slight		No prominence.
	26	11	28	20·5		W	1·0	2·0		To red at top ; to violet at base.
	27	10	50	23		W	1·0			At top.
	27	10	49	27		W		1·0		At base.
	28	10	18	1·5		E		0·5		Do.
	28	8	54	42		W		0·5		Do.
	28	8	47	76		W	0·5			Do.
	28	8	43	85		W	0·5			Do.
	29	8	45	85		E	0·5			At top.
	29	9	55	3·5		E		1·0		At base.
	29	9	47		13	E	1·0	4·0		Do.
	29	11	22		18	E	3·0	2·0		Do.
	29	11	22		27	E	1·0			Do.
	29	8	48	76		W	0 5			
	30	9	22	45·5		E		0·5		At base.
	30	9	20	23		E	0·5			At top.
	30	9	22	4		W	0·5			Do.
	31	8	52	83		E	1·0			Do.
	31	9	1	60·5		E		Slight		
	31	9	0	48·5		E		0·5		At base.
	31	9	14	26		E		1·0		At top.
	31	9	12	14		E	0·5	0·5		To red at top ; to violet at base.
	31	9	33		19	E	0·5			At base.
February	1	9	9	24		E	3·0	2·5		To red at base ; to violet at top.
	1	9	12	8·5		E		1·5		At top.
	1	9	24		5	W	1·5			Do.
	2	8	30	65·5		E		Slight		
	2	9	2	12		E		1·0		At top.
	2	9	10	9		E	1·0			Do.
	2	9	44		4	E		1·0		Do.
	2	8	48		10	W		0·5		Do.
	2	9	5	26		W	0·5			Do.
	3	9	5	12		E	1·0	3·0		At base.
	3	9	6	6		E		1·0		Do.
	3	10	21		13	E	1·0	1·0		To red at top ; to violet at base.
	3	9	50	30		W			0·5	
	3	9	44	35		W		1·0		At base.
	4	9	50	32		E	Slight			
	4	10	16		10	W	1·0	0·5		To red at top ; to violet at base.
	5	8	54	32		E	1·0			
	5	8	54	15		E	0·5			
	5	8	50		19	W	1·0	2·0		To red at top ; to violet at base.
	5	8	50		11	W	2·0			At top.
	6	9	2	30		E		0·5		At base.
	6	9	35	13		E	0·5			Do.
	6	9	28		18	W	Slight			At top.
	6	10	42	53·5		W		0·5		Do.
	7	9	24	19		E	Slight			Do.
	7	9	30	3		W	1·0			Do.
	7	9	30	20		W	0·5			Do.
	8	9	26	39·5		E	0·5			Do.
	8	9	39		24	E		3·0		Do.
	8	9	39		28	E	4·0			At base.

Date.		Hour I.S.T.	Latitude. North.	Latitude. South.	Limb.	Displacement. Red.	Displacement. Violet.	Displacement. Both ways.	Remarks.
1927.		H. M.	°	°		A.	A.	A.	
February	9	8 54	45·5		E	1·0			At base.
	9	9 0	25		E		1·0		At top.
	11	9 15		27	W	2·0			At base.
	11	9 12		23	W	1·0			Do.
	11	9 10		15	W	1·0			Do.
	13	9 10	56·5		E	0·5			Do.
	13	9 12	34·5		E	2·0			Do.
	13	9 12	33·0		E		1·5		At top.
	13	9 19		78	W		1·0		Do.
	13	9 9		40·5	W		1·0		Do.
	13	9 9		38·5	W	1·0			At base.
	13	9 4		22	W	1·0			Do.
	14	9 2	61		E		0·5		At top.
	14	9 7	25		E	0·5	1·0		To red at base ; to violet at top.
	14	9 30	21		E		1·0		At top.
	14	9 30	18		E	1·5			At base.
	14	9 11	13		E	0·5			Do.
	14	8 49		2	E	1·0			Do.
	14	8 46		40·5	E		1·0		At top.
	14	8 56		23	W		0·5		Do.
	14	8 52	14		W	0·5			Do.
	14	9 20	16		W	1·0			Do.
	14	9 20	18		W		0·5		At base.
	14	8 45	44·5		W		0·5		At top.
	15	8 24	61		E		Slight		
	15	9 6	5		W	2·0			At top.
	15	9 6	8		W		1·0		At base.
	15	8 42	18		W	1·5	1·0		To red at top ; to violet at base.
	15	8 32	75·5		W		0·5		
	15	8 28	83		W	1·5			At top.
	16	9 12	13·5		E	2·0	1·0		To red at top ; to violet at base.
	16	8 52		8·5	W	2·5	1·0		Do.
	17	9 15	6		W		1·0		Over whole prominence.
	20	8 20	63		E	Slight			
	20	8 39	24		E	1·0			At base.
	20	8 45	11		E		1·0		At top.
	20	9 20		29	W	Slight			Do.
	21	9 30	33·5		E	1·0			At base.
	21	9 34	9		E	3·0			At top.
	21	9 40		38·5	E	1·5			At base.
	21	9 42		43·5	E	Slight			
	21	9 1	39·5		W	1·0			At top.
	22	8 37	67		E		Slight		At base.
	22	9 21		12	E	1·0			At top.
	22	9 23		15	E	0·5			Do.
	22	9 26		36·5	E	1·5			At base.
	22	8 54	36		W	1·0	1·5		To red at top ; to violet at base.
	22	8 50	75·5		W	0·5			At top.
	23	8 25	30		E	1·0			Do.
	23	8 40	16·5		E	2·0	0·5		To red at base ; to violet at top.
	23	8 40	13		E		1·0		At top.
	23	8 32		19	E	1·0			At base.
	23	9 46		37·5	W	1·5			At top.
	23	9 46		29	W	2·0			Do.
	23	8 50	27		W	1·5	1·0		To red at base ; to violet at top.
	24	10 5		15	E	1·0	0·5		Do.
	24	10 15		17	W		0·5		At base.
	27	9 15		3	E		1·0		At top.
	27	9 28		23	E	1·5	1·0		To red at base ; to violet at top.
	27	9 0	30		W	2·0			At top.
	27	9 0	31·5		W		1·5		At base.
	27	8 53	48·5		W	1·5	1·0		To red at base ; to violet at top.
	28	10 30	20		E	1·5	1·0		Do.
	28	9 2		11	W		1·0		At top.
	28	8 58	51·5		W		0·5		Do.
March	1	8 42	47·5		E		1·0		At base.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1927.		H.	M.	°	°		A.	A.	A.	
March	1	9	10		19	E	0·5			At top.
	1	8	51		14	W	Slight			Do.
	5	9	3		26	W	0·5			
	5	9	12		30·5	W		0·5		
	5	9	50	44·5		W	1·0			
	6	8	54	26		E		0·5		At base.
	6	9	3		11	W	1·0			At top.
	9	8	26		20	W	1·0			Do.
	9	8	24		11	W	1·0			Do.
	9	8	22	11		W		2·0		At base.
	10	8	40	25		E		0·5		
	11	8	58	25		E		1·0		At top.
	11	9	3	1		E	1·0	1·5		To red at base ; to violet at top.
	12	10	1	31·5		E		1·0		At top.
	13	9	25	33·5		E	3·0			Do.
	13	9	8	33·5		E	1·0	1·5		To red at top ; to violet at base.
	13	8	48	24		W	1·0			At top.
	13	8	45	28		W	2·0			Do.
	13	8	45	30·5		W		1·0		At base.
	13	8	41	35·5		W	1·0			At top.
	14	9	50	60		E	2·5	1·0		To red at top ; to violet at base.
	14	9	28	51·5		E		4·5		At top.
	14	9	14	36·5		E	20·0	5		To red at base ; to violet at top.
	14	10	4		41·5	W	2			At top.
	15	9	0	55·5		E	1	2		To red at top ; to violet at base.
	15	9	12	39·5		E	1	1·5		To red at base ; to violet at top.
	15	9	26		10·5	W	1·5	1		To red at top ; to violet at base.
	15	9	9		7	W	1			At top.
	16	10	6		10	W	0·5			Do.
	17	9	31	20		E		1		Do.
	17	9	29	8		E		1		Do.
	18	8	58	70·5		E		0·5		At base.
	18	9	30	40·5		E		1		At top.
	18	9	16		6	E	0·5			At base.
	18	9	17		16	E		1		At top.
	18	9	6		35·5	W		1		At base.
	18	9	23		35·5	W	1	1·5		At top.
	19	10	16	14		W	3			No prominence.
	19	10	35	16		W	1			At top.
	20	8	50	30		E	0·5			At base.
	20	9	15		79·5	E	0·5			Do.
	21	9	3	55·5		E		0·5		Do.
	21	9	19	34·5		E	1			At top.
	21	9	8	55·5		W	0·5			Do.
	22	9	7	51·5		E	0·5			At base.
	22	9	10	31·5		E	0·5			Do.
	22	9	0	38·5		W	1			At top.
	23	9	3	71·5		E	Slight			At base.
	23	9	9	12		E		1		At top.
	23	9	1		11	W	0·5			Do.
	24	9	9	60		E	1			Do.
	24	9	9	57·5		E		0·5		At base.
	24	9	31		30	W	0·5			At top.
	25	9	24	81		E	0·5			Do.
	25	9	9	57·5		E	1			Do.
	25	9	29	33·5		E		2		Do
	25	9	31	20		E		0·5		Do.
	25	9	19		26	W	2			Do.
	25	9	17		9	W	1			Do.
	26	9	48	7		E	Slight			Do.
	26	9	45		1	E	1			At base.
	26	9	33		74·5	E	0·5			No prominence.
	27	8	45	30		E	1			At top.
	27	9	24		74·5	E	0·5			At base.
	27	9	8		8	W	1			At top.
	27	9	0	30		W	6	2		At base.
	27	9	0	37		W	3			At top.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1927.		H.	M.	°	°		A.	A.	A.	
March	28	8	58	30 5		E	1			At top.
	28	9	7	26		W	1			Do.
	28	8	52	37·5		W	1			Do.
	28	9	4	69		W		0·5		At base.
	30	10	27		6·5	W	Slight			At top.
	31	10	7	49		E		1		Do.
	31	9	20	26·5		E	2	2		To red at base ; to violet at top.
	31	9	23	20		E			1·5	
	31	9	24	12		E	2			Throughout top portion.
	31	9	4		50	E		Slight		At top.
April	1	9	44	9		E		1		At top.
	1	9	38		5	W	0·5			Do.
	1	9	30	36·5		W		0·5		At base.
	2	9	19	49·5		E		1		At top
	2	9	23	22		E	1·5			At base.
	2	9	21	15		E	1			Do.
	2	9	25		37·5	E		2		At top.
	2	9	15		82·5	E	1			Do.
	2	9	7		12	W	2	1		To red at base ; to violet at top.
	3	9	20	30		E	1			At top.
	3	9	18	6		E	0·5			Do.
	3	9	33		44 5	E		1		Do.
	4	8	40	69		E	1·5			Do.
	4	8	51		14	E	0·5			At base.
	4	8	45	8		W		1		Do.
	5	9	35	76·5		E		0·5		Do.
	5	9	30		11·5	E	1·5	1		To red at base ; to violet at top.
	5	9	44		21	W		1·5		At base.
	6	10	43	23		E	1			At top.
	6	9	37		11	E	4			Do.
	6	9	47		16	E			6	
	6	9	34		16	E		4		At base.
	6	9	35		18	E	1			At top
	6	9	24		83	W		1		Over middle of prominence.
	6	10	58		22	W		4·5		At top.
	7	10	35	23		E	1	1		To red at top ; to violet at base.
	7	10	37	15		E		1		At top.
	7	10	21		13·5	E		1		Do.
	8	8	55	20		E	1			Do.
	8	8	40		72·5	E		0·5		Do.
	8	8	31		17	W		1		At base.
	8	8	31		15	W	1			At top.
	9	10	35		10	E	3			Over whole prominence.
	9	10	26		6	W	1			At top.
	10	9	20	38		E	1			Do.
	10	9	12	30·5		E		1		At base.
	10	9	6	19		E		2		Do.
	10	9	6	16		E	1·5			At top.
	10	9	6	13		E		1		At base.
	10	9	30	13		E	2			At top.
	10	9	32		4	E		2		Do.
	10	9	26	23		W		0·5		At base.
	11	8	24	48·5		E		1·5		At top.
	11	8	24	38		E	1			At base.
	11	8	26	12		E	0·5			Do.
	11	8	31		33	W	0·5			Do.
	12	8	24	66·5		E		Slight		
	12	8	45	27		E		0·5		
	12	8	50		31	E	0·5			At base.
	12	8	33	2		W			1	
	13	10	45	43·5		E	1	1		To red at base ; to violet at top.
	13	10	43	37		E	0·5			At base.
	13	10	41	28		E		Slight		At top.
	13	10	33	10		E		1·5		Do.
	13	10	11		26	E	1			At base.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North	South		Red.	Violet ;	Both ways.	
1927.		H.	M.	°	°		A	A.	A.	
April	13	10	50	13·5		W	Slight			At top.
	13	11	6	73		W	2			Do.
	14	9	46	47		E		1		Do.
	14	9	38	37		E	1			Do.
	14	9	20		11	E		0·5		At base.
	14	9	17		27	E	1			At top.
	14	10	10	12·5		W	Slight			Do.
	15	9	0	27		E		Slight		No prominence.
	15	8	58	11		E	1			At top.
	15	9	4	62·5		W		1		At base.
	16	9	2	44·5		E	0 5			At top.
	16	9	16	6		E	Slight			Do.
	16	9	9	15		W	0·5			Do.
	17	8	48	83·5		E		0·5		At base.
	17	8	45	17		E	1			At top.
	17	9	0	10		E	0·5			At base.
	17	8	54	2		W	1			
	18	9	52	57·5		E		Slight		At base.
	18	9	19	24		E		Slight		At top.
	18	8	48	14		E	0·5			Do.
	18	8	57	19		W	1			Do.
	19	8	32	72		E	0·5			Do.
	19	8	37		17	W	2	1·5		To red at top ; to violet at base.
	19	8	37		13	W	3			At top.
	20	10	8	3		E	1			Do.
	20	9	50		11	E	Slight			At base.
	20	9	55		24	E		2		At top.
	20	10	18		22	W	1			Do.
	20	10	21		14	W	2	1		To red at top ; to violet at base.
	20	10	35	37		W			1	At top.
	21	10	10	43·5		E	0·5			Do.
	21	11	20		2	E	2			At base.
	21	9	50		19	E		1		At top.
	21	10	26	25·5		W		1		Do.
	21	10	30	43		W	0·5			Do.
	22	8	21	64·5		E		0·5		
	22	8	45		29	E	1			At top.
	24	8	34	25		E		1		Do.
	24	8	50	23		E	0·5			At base.
	24	8	32	8·5		E	0 5			Do.
	24	9	7		43	E		0·5		Do.
	24	8	45		18	W		3		Do.
	24	8	45		16	W	1·5			At top.
	24	8	40	25		W	0·5			Do.
	24	8	38	31		W	1			Do.
	25	9	55	4		E	0 5			At base.
	25	9	57		10	E		1		At top.
	25	9	31	50		W	Slight			
	30	9	54	36		E	Slight			At base.
May	1	8	25	18		E		0·5		At base.
	1	8	23	10		E	1			At top.
	1	8	30	68·5		W	1			Do.
	3	9	32	35		E	0·5			Do.
	6	8	44	52		W	0·5			Do.
	7	9	32		4	E	1·5	0·5		To red at top ; to violet at base.
	7	9	36		10	E	0·5			At base.
	7	9	18		36	E	1			At top.
	7	9	15		52	E	0·5			Do.
	7	9	49		4	W	Slight			Do.
	8	9	43	32		E		0·5		At base.
	8	10	0		12	E	1·5	2·5		To red at base ; to violet at top.
	8	9	50		18	W	1			At top.
	8	10	10		18	W	2	3		To red at base ; to violet at top.
	9	8	44	20		E	1			At top.
	9	11	45		23	W	2			Do.
	10	9	38		17	E		1·5		Do.

Date.	Hour I.S.T.	Latitude.		Limb.	Displacement.			Remarks.
		North.	South.		Red.	Violet.	Both ways.	
1927.	H. M.	°	°		A.	A.	A.	
May 10	9 34		27	E	1			At top.
10	9 24		62	E	0·5			Do.
10	10 1		46	W		0·5		At base.
11	9 27		42	E		Slight		Do.
11	9 54		24·5	W	0·5			At top.
11	10 3	10		W	0·5			Do.
12	9 52		14·5	E	1	1		To red at base; to violet at top.
12	10 9	49·5		W		1		At top.
13	9 29		21	E		1·5		Do.
13	9 21	15		W	1			Do.
14	9 38	59·5		E	0·5			Do.
14	9 27		24	E	Slight			Do.
14	9 53		13·5	W	1	0·5		Do.
15	9 7	56		E	Slight			
15	8 49	40		E		Slight		
15	8 47	31		E		0·5		At base.
15	9 2		16	E	0·5			
15	9 10		30	E	0·5			At base.
15	8 55		21	W	0·5			
15	8 53		11	W	1			At top.
16	10 54	45		E	0·5			Do.
16	10 59	26		W	1			Do.
17	10 8	67		E	0·5			Do.
17	10 0		35	E	Slight			Do.
17	10 20		55	W	0·5			Do.
17	10 23		13	W		Slight		At base.
17	10 24		13	W	1			At top.
17	10 26	10		W	1			Do.
18	10 12		8	E		0·5		At base.
18	10 36		21·5	W	1	0·5		To red at top; to violet at base.
20	8 58	18		E	Slight			At top.
20	9 25		47	E	1			At base.
20	9 10		70	W		1		Do.
20	9 2	15		W	1			At top.
21	9 32	14		E		0·5		Do.
21	9 25		19	E		1		At base.
21	9 22		47	E	1	0 5		At top.
21	9 15		61	E	Slight			Do.
21	9 55	19		W	1			Do.
21	9 58	57		W	0·5			Do.
22	9 12	26		E		0 5		At base.
22	9 15		18	E		1		At top.
22	9 8		67	W		Slight		
22	9 3		5	W	0·5			At top.
24	9 28	22		E	0·5			Do.
24	9 26		24	E	0·5	1		Do.
24	9 6		86 5	W		Slight		At base.
25	9 25	17·5		E		0·5		Do.
25	9 5		87·5	W		1		At top.
25	9 41		34	W	1			Do.
25	9 46		26	W	1	0·5		To red at top; to violet at base.
26	11 20	51		W		1		At base.
27	9 11	16		W	Slight			At top.
28	9 20	43		E		1		Do.
28	9 13	14		E		0·5		At base.
28	9 12		11	E		Slight		Do.
28	9 31		22	W	1			At top.
28	9 33		10	W	0·5			Do.
29	9 33		38	W		1		Do.
30	9 2	14		E		1		At base.
30	9 24		58	E	0·5			Do.
June 6	8 54	80		E		Slight		At base.
6	9 12		25	W		Do.		At top.
6	9 4	35		W		0·5		At base.
6	9 1	49		W	Slight			At top.
7	9 46	43		E	0·5	1		Do.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1927.		H.	M.	°	°		A.	A.	A.	
June	7	9	43		8	E	0·5			At top.
	7	9	41		32	E		1		Do.
	8	9	22	10		E	Slight			Do.
	8	9	20		13	E	0·5			Do.
	8	9	40		9·5	W	0·5			Do.
	8	9	43	39		W	1			Do.
	9	9	19	47		E		Slight		Do.
	9	9	58		33	W		Do.		In the chromosphere.
	9	9	36	6		W	Slight			At top.
	9	9	44	58·5		W		1		Do.
	10	8	47	54		E	1			Do.
	10	8	46	45		E	Slight			Do.
	12	11	26	29		E	1			Do.
	15	9	2		36	E		0·5		At base.
	15	9	1		42	E		1		At top.
	15	8	58		72	E		Slight		Do.
	15	9	50		16	W	1·5			Do.
	15	9	52	18		W	1			Do.
	19	8	54	12		E	0·5			
	19	8	55		6	E	0·5			At base.
	19	8	51	17		W	0·5	0·5		
	19	8	50	56		W				
	21	10	13	50		E	1			At top.
	21	10	3		20	E		0·5		Do.
	24	9	56		20	W	1			Do.
	26	9	49		7	E		1		Do.
	26	10	2		17	E	1			At base.
	27	10	2	9		W		0·5		Do.
	28	9	58	36		E		0·5		Do.

The total number of displacements was 535 as against 230 in the previous half-year, and their distribution was as follows :—

Latitude.	North.	South.
1°—30°	169	167
31°—60°	111	38
61°—90°	35	15
Total ...	315	220

East limb	312
West limb	223
Total ...	535

Three hundred and six displacements were towards the red, 224 towards the violet and 5 both ways simultaneously.

Reversals and displacements on the Sun's disc.

Five hundred and ten bright reversals of $H\alpha$ line, 382 dark reversals of D_3 line and 214 displacements of $H\alpha$ line were observed during the half-year. Their distribution is given below :—

	North.	South.	East.	West.
Bright reversals of $H\alpha$	216	294	264	246
Dark reversals of D_3	149	233	204	178
Displacements of $H\alpha$	93	121	124	90

One hundred and fifty-one displacements were towards the red, 61 towards the violet and 2 both ways simultaneously.

The Eruptive Prominence of 14th March 1927.

A remarkable eruptive prominence was photographed on the 14th March 1927. At $8^h 40^m$ I.S.T. and at $8^h 53^m$ low prominences were photographed between 30° and 53° in the north-east quadrant the highest part reaching to 1′ 5″ above the chromosphere. The next photograph taken at $9^h 18^m$ shows a large irregular prominence reaching to 6′ 55″, a rise of 254,000 kms. in 25 minutes or less. From this time photographs were taken as rapidly as possible until $11^h 13^m$ when it had almost completely subsided. Making visual observations with a prominence spectroscope Mr. S. Balasundaram Ayyar noted a displacement of the C line extending from 5 A to the violet to as far as 20 A to the red. This is one of the largest displacements ever recorded and although lasting only a few minutes the magnitude of the displacement was confirmed by other observers. The helium line D_3 was displaced as far as the sodium line D_2. The displacements of the C line indicate velocities in the prominence ranging from 230 kms. per second towards the earth to 915 kms. per second away from the earth. The existence of these large displacements prevents the true forms and velocities in the prominence being shown in the spectroheliograms. This view is supported by the difficulty of recognizing identical parts of the prominence in succeeding photographs and also by the fact that although the prominence was growing in height between $8^h 53^m$ and $10^h 14^m$, individual parts were either stationary or descending. After $10^h 14^m$ the height of the prominence diminished and the parts which could be identified in successive photographs indicated descent whilst the prominence as a whole became fainter. At $11^h 13^m$ it was faint with a height of only 3′ 46″. Throughout the whole time of these rapid changes, a small prominence at 51°—53° NE remained unchanged with a height of about 40″.

Prominences projected on the disc as absorption markings.

Photographs of the Sun's disc in $H\alpha$ light were available from Kodaikanal and the co-operating observatories for a total of 176 days, which were counted as 171 effective days. The mean daily areas of $H\alpha$ absorption markings (corrected for foreshortening) in millionths of the Sun's visible hemisphere and the mean daily numbers are given below :—

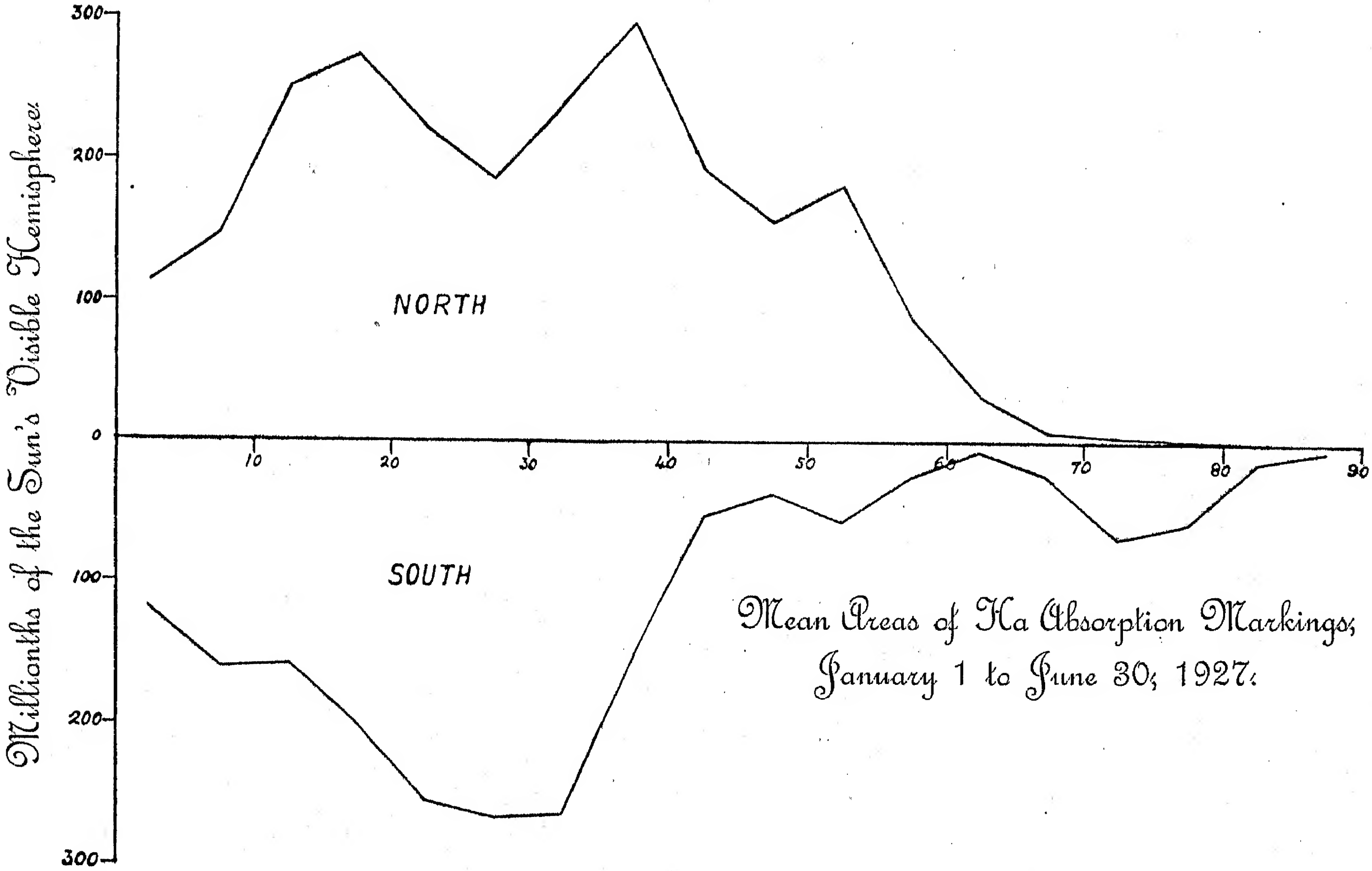
	Mean daily areas.	Mean daily numbers.
North	2,386	19·9
South	1,911	19·2
Total ...	4,297	39·1

The above figures show an increase of 15 per cent in areas and 19 per cent in numbers compared with the previous half-year.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 154 days of observation being reckoned as 150½ effective days.

		Mean daily areas.	Mean daily numbers.
North (Kodaikanal photographs only)	... ...	2,395	20·3
South do.	... ...	1,961	20·1
	Total ...	4,356	40·4

The distribution of the mean daily areas in latitude is shown in the following diagram. There are two zones of activity in the northern hemisphere near 20° and 40°, while the maximum of activity in the southern hemisphere is about 30°. The prominence activity in high latitudes has no counterpart in the northern hemisphere but persists in the southern.



The activity was in excess in the eastern hemisphere, the percentage east being 50·96 in the case of numbers and 51·05 in the case of areas.

Thanks are due to the co-operating observatories for the photographs supplied by them.

THE OBSERVATORY, KODAIKANAL,
19th February 1928.

T. ROYDS,
Director, Kodaikanal and Madras Observatories.

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Kodaikanal Observatory.

BULLETIN No. LXXXIV.

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE SECOND HALF OF THE YEAR 1927.

In pursuance of the programme of work adopted since 1st January 1923 under the auspices of the International Astronomical Union, all observatories taking spectroheliograms of the sun have been asked to co-operate with the Kodaikanal Observatory by supplying copies of their photographs on those days when the Kodaikanal records are imperfect or wanting. In response to our requirements for the second half of the year 1927, the Mount Wilson Observatory supplied prominence plates for 49 days and Hα disc plates for 35 days; Meudon Observatory supplied K_3 disc plates for 6 days and Hα disc plates for 10 days; and the Pitch Hill Observatory (Mr. Evershed's) at Ewhurst, Surrey, England, supplied 10 prominence plates and 3 Hα disc plates.

When only incomplete or imperfect photographs for any day are available from more than one observatory, the best photograph is chosen as representing the solar activity of that day after weighting it according to its quality, and the remaining photographs are ignored.

The mean daily areas and numbers of prominences during the half-year are given below. The means are corrected for incomplete or imperfect observations, the total of 181 days for which plates were available being reduced to 155 effective days.

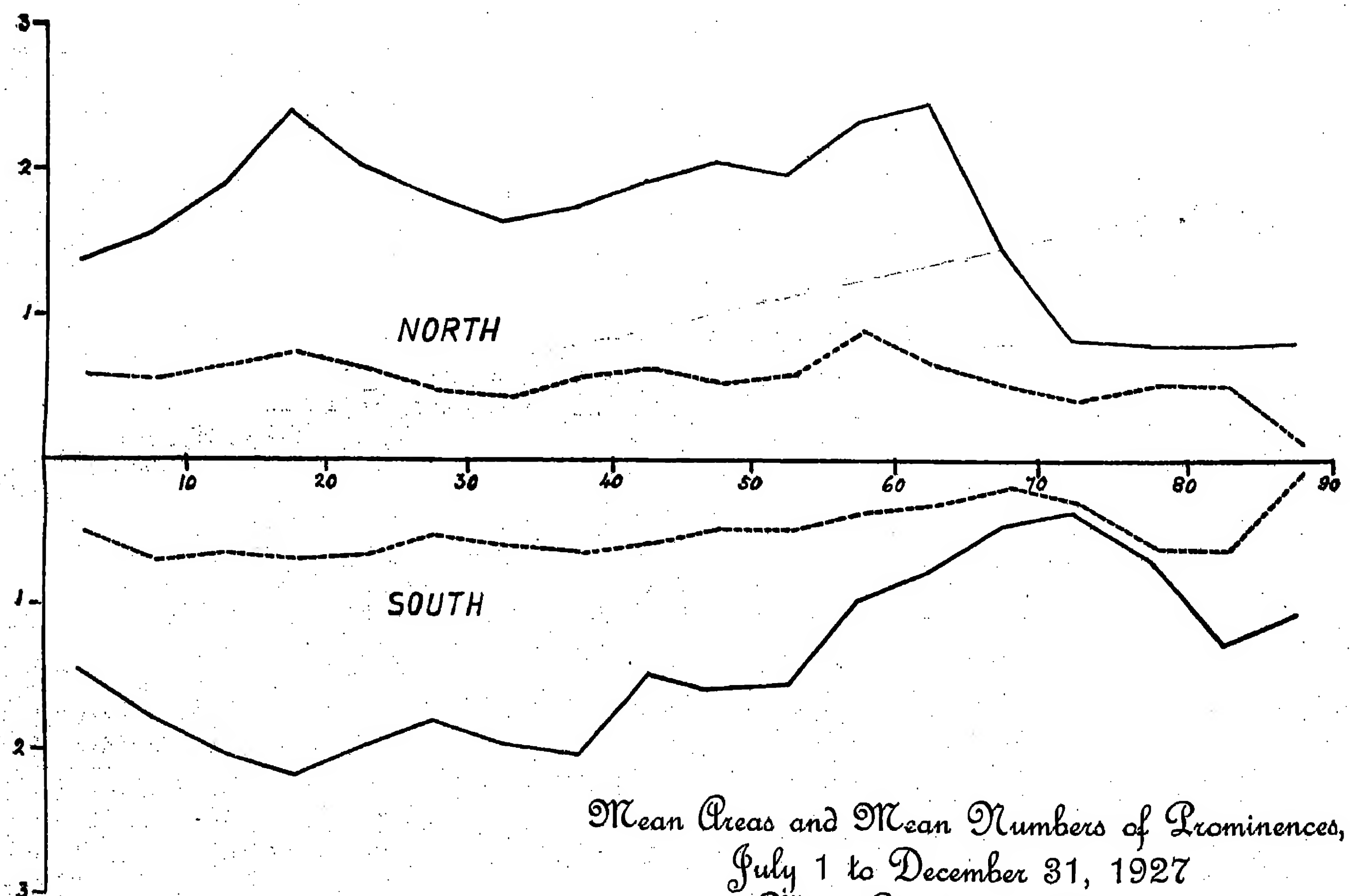
	Mean daily areas (square minutes).	Mean daily numbers.
North	2·97	9·99
South	2·54	9·04
Total ...	5·51	19·03

Compared with the first half of the year, areas show a decrease of about 27 per cent in both hemispheres, and numbers show a slight decrease in the southern hemisphere only.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 145 days of observation being counted as $129\frac{1}{2}$ effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North (Kodaikanal photographs only)	3·03	10·34
South (do.)	2·47	9·39
Total ...	5·50	19·73

The distribution of prominences in latitude is represented in the following diagram, in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude. The ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line. The high latitude activity typical of the period of maximum activity of the sunspot cycle is still evident in prominence numbers although much reduced according to prominence areas when compared with the first half of the year. The areas in the belt 0°-5° North and South of the equator are about one-half of those in the first half of the year.



Mean Areas and Mean Numbers of Prominences,
July 1 to December 31, 1927
Mean Areas ______ full line
Mean Numbers ----- broken line.

The monthly, quarterly and half-yearly areas and numbers, and the mean height and mean extent of the prominences on photographs from all the co-operating observatories are given in Table I. The unit of area is 1 square minute of arc. The mean height is derived by adding together the greatest heights reached by individual prominences and dividing by the total number of prominences observed; the mean extent is derived by adding together the lengths of the base on the chromosphere of individual prominences and dividing by the total number of prominences.

TABLE I.—ABSTRACT FOR THE SECOND HALF OF 1927.

Months.	Number of days (effective).	Areas.	Numbers.	Daily Means.		Mean height.	Mean extent.
				Areas.	Numbers.		
1927.						″	°
July	23¾	169·3	408	7·1	17·1	33·0	4·75
August	23¼	119·4	511	5·1	21·9	34·5	4·15
September	25½	147 1	507	5·9	19 9	33 9	4·80
October	27	135·0	472	5·0	17·5	35 5	4·98
November	26	108·8	537	4·2	20·7	32·8	4·09
December	29½	174·4	516	5·9	17·5	38·1	5·36
Third quarter	72½	435·8	1426	6·0	19·7	33·9	4 55
Fourth quarter	82½	418·2	1525	5·1	18·5	35·4	4·80
Second half-year	155	854·0	2951	5·5	19·0	34·7	4·68

Distribution east and west of the Sun's axis.

During the half-year both areas and numbers showed a slight excess at the western limb compared with the eastern limb as will be seen from the following table :—

1927 July to December.	East.	West.	Percentage East.
Total number observed	1428	1525	48·4
Total areas in square minutes	418·6	435·2	49·0

Metallic prominences.

Eighteen metallic prominences were observed during the half-year. Their details are given below :—

TABLE II.—LIST OF METALLIC PROMINENCES OBSERVED AT KODAIKANAL, JULY TO DECEMBER 1927.

Date.		Hour I.S.T.		Base.	Latitude.		Limb.	Height.	Lines.
					North.	South.			
1927.		H.	M.	°	°	°		"	
July	15	9	8	4		11	W	15	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5276·0, 5263·0, 5316·8, D_2, D_1.
August	30	8	28	2		10	W	10	6677 and 7065 only.
	31	9	0	6		10	W	20	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5276·0, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
September	4	8	46	4		13	E	20	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5276·0, 5316·8, 5363·0, D_2, D, 6677, 7065.
	13	8	37	4		4	E	20	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5276·0, 5316·8, 5363·0, D_2, D_1, 7065.
	14	9	34	3	30·5		E	10	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·9, 5276·0, 5316·8, 5363·0, D_2. D_1.
	19	9	10	3		16·5	E	20	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5233·0, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
October	2	9	8	2	18		W	15	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5276·0, 5316·8, 5363·0, 6677, 7065.
	8	9	20	1		9·5	E	10	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·0, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	12	9	25	4		2	E	20	b_4, b_3, b_2, b_1, 5316·8, D_2, D_1.
	16	11	46	3	16·5		W	20	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1 5276·0, 5316·8, D_2, D_1, 6677, 7065.
November	15	9	30	1		20·5	W	5	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·0, 5316·8, 5363·0, D_2, D_1.
	16	9	6	3		20·5	W	20	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5227·4, 5269·8, 5276·0, 5363·0, D_2, D_1, 6677.
	22	9	43	1	1·5		W	5	b_4, b_3, b_2, b_1, D_2, D_1, faintly reserved.
	26	9	41	1	30·5		E	5	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5269·8, 5276·0, 5316·8, 5328·6, 5363·0, D_2, D_1, 7065.
	27	9	14	3	31·5		E	10	5016, 5018·6, b_4, b_3, b_2, b_1, 5276·0, 5316·8, D_2, D_1.
December	27	10	5	1		3·5	E	15	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 7065.
	28	9	40	3		1·5	E	5	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.

The distribution in latitude of the metallic prominences was as follows :—

	1°—10°	11°—20°	21°—30°	31°—40°	Mean latitude.	Extreme latitudes.
North	1	2	2	1	21°·4	1°·5 and 31°·5
South	7	5	0	0	10°·9	1°·5 and 20°·5

Ten were on the east limb and 8 on the west limb.

Displacements of the hydrogen lines.

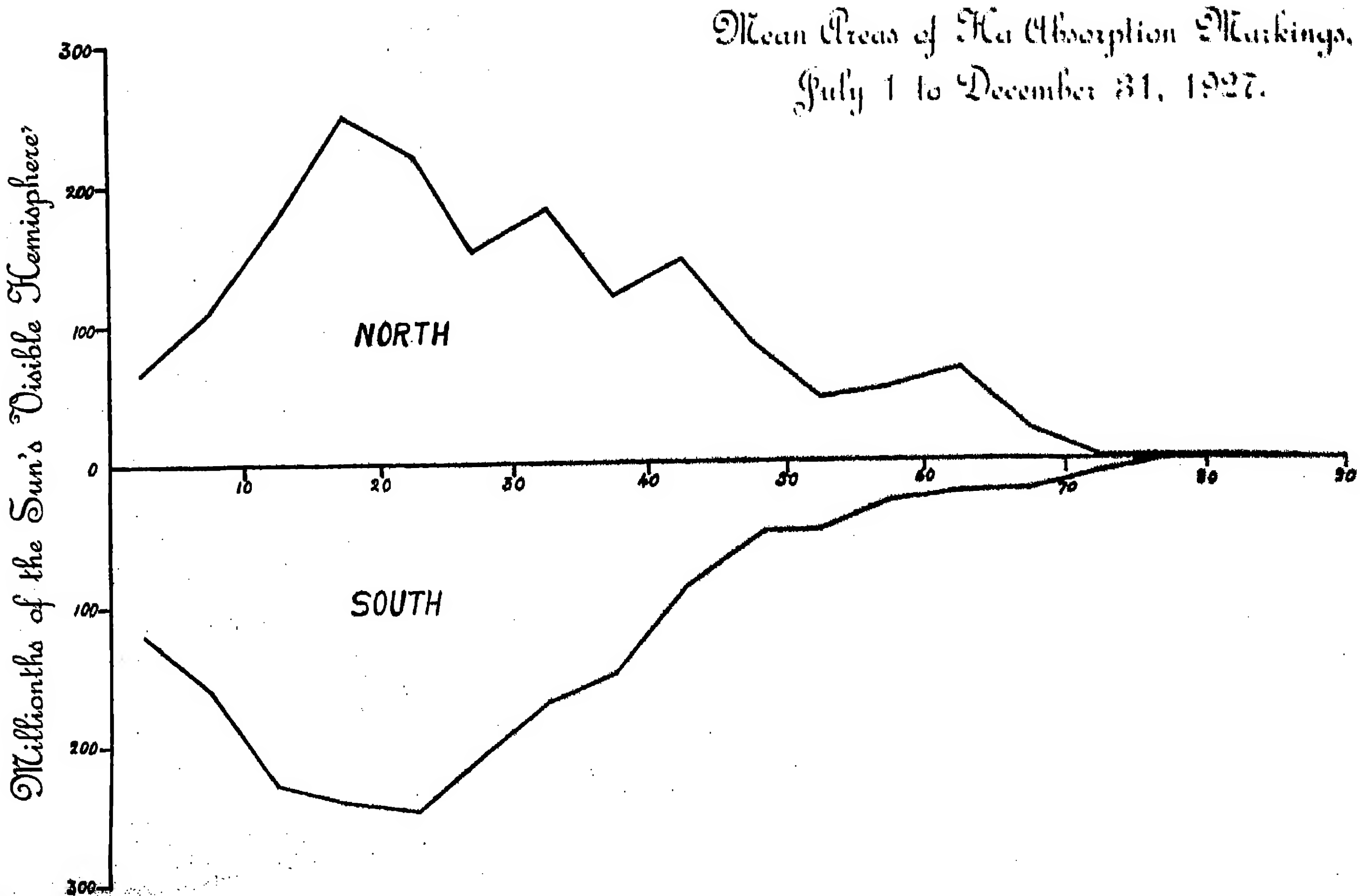
Particulars of the displacements observed in the chromosphere and prominences are given in the following table :—

TABLE III.—DISPLACEMENTS OF THE HYDROGEN LINES.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways	
1927.		H.	M.	°	°		A.	A.	A.	
July	14	9	1		28	E		Slight		At top.
	15	8	54	65·5		E		Slight		No prominence.
	15	9	16		11	W		1		At base.
	15	9	0	34		W	0·5			At top.
	18	9	52		39	W		Slight		At base.
	28	11	28		13	W	1			At top.
	29	9	40		9	E		0·5		Do.
	29	9	43		50·5	E	1			At base.
August	3	9	20		72	E		Slight		At top.
	4	9	41		34	E	0·5			Do.
	5	9	57	21		W	1	2		To red at top ; to violet at base.
	7	9	31		38	W	1			At top.
	7	9	27	11		W		0·5		At base.
	7	9	38	33		W	1·5			Do.
	8	9	46	13		W		1		Do.
	9	11	25		20	W	1	1·5		To red at top ; to violet at base.
	17	9	51		11	E	Slight			In chromosphere.
	17	9	36		36	W	0·5			At base.
	18	9	12		16	E	1	0·5		To red at base ; to violet at top.
	19	9	6	24		E		0·5		At top.
	19	9	0		22	W		Slight		At base.
	22	10	30	22		E	1			At top.
	22	10	28		28	W	0·5			Do.
	23	8	39	18		E	1·5			Do.
	23	8	29		55	W		Slight		
	23	8	23		31·5	W		0·5		At base
	23	8	22		30	W	0·5			At top.
	25	10	40	8		W	2			Do.
	26	10	19		16	E		1		Do.
	26	10	23		50	E	2	1		To red at base ; to violet at top.
	26	8	40	24		W	0·5			At top.
	26	8	32	59		W	0·5			Do.
	29	9	16	83		E	0·5			At base.
	29	9	3	62		E		0·5		Do.
	29	9	20	6		E	1			Do.
	30	8	24	80		E		Slight		
	30	9	0		14	E	0·5			At base.
	30	8	40		36·5	W	0·5	1		To red at base ; to violet at top.
	30	8	28	76		W		1		At base.
	31	9	0		13·5	W	2			At top.
	31	9	0		9	W		4		At base.
	31	8	54	24		W	1			At top.
September	2	8	24	65		W	0·5			
	4	9	12	44·5		E	0·5			At base.
	4	9	14	38·5		E	Slight			Do.
	4	9	16		3	E		1·5		At top.
	4	8	40		10	E	1	3		To red at base ; to violet at top.
	4	9	1		13	E	10			At base.
	4	9	18		9	E		8		At top.
	5	8	34		11	E	1	2		To red at base ; to violet at top.
	5	8	48		43·5	W	0·5			At top.
	5	8	32	34		W	1			Do.
	6	9	15		68	W		Slight		At base.
	7	9	22	35		W	1			At top.
	9	9	34		9	W		1		At base.
	9	9	27	58·5		W		Slight		Do.
	9	9	15	82		W	0·5			At top.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1927.		H.	M.	°	°		A.	A.	A.	
September	10	10	5		60	W	1			At top.
	11	8	27	75·5		E		0·5		Do.
	11	8	27	73·5		E	Slight			At base.
	11	8	35		9	E	1			Do.
	11	8	21		17	W	1			At top.
	11	8	17	77·5		W	0·5			Do.
	12	10	2	22		E	0·5			Do.
	12	9	48	82·5		W	0·5			Do.
	13	8	21	60·5		E	Slight			
	13	9	20	24		E	0·5			At base.
	13	9	24	18		E	1·5	1		To red at base ; to violet at top.
	13	8	37		5	E	Slight			At base.
	14	9	45	38·5		E	1			
	14	9	43	24		E		0·5		At top.
	14	9	14		6	E		1		Do.
	15	10	36		13	E		1		Do.
	15	10	45		68	E	Slight			At base.
	15	9	58		18	W			1	
	19	8	52	61		E	0·5			At top.
	19	9	7	17		E	2	3		To red at base ; to violet at top.
	19	9	3		8	W		0·5		At base.
	19	8	58	45·5		W	1			At top.
	20	10	40	52·5		E	Slight			At base.
	20	10	58		18	W	1	1		To red at base ; to violet at top.
	20	10	58		13	W	1			At top.
	20	10	45	77		W	Slight			
	21	9	20	69		E		Slight		
	25	8	53	53		W	0·5			At top.
October	2	9	20	81·5		E		Slight		
	2	9	22	23		E	1			At base.
	2	9	24	17		E		1		At top.
	2	9	32	16		E	1			At base.
	2	9	26	12		E	1			Do.
	2	9	18		73·5	W	Slight			At top.
	2	9	3	18		W	2·5			Do.
	2	9	14	20		W		1		At base.
	2	9	1	42·5		W		Slight		Do.
	3	9	7	69		E	0·5			At top.
	3	9	21		19	E	0·5			At base.
	3	9	12	14		W	1·5	1		To red at top ; to violet at base.
	3	9	9	72		W		Slight		At base.
	4	9	41		3·5	E			1	At top.
	4	9	40		7·5	E			1	Do.
	4	9	13		22	W	2			Do.
	5	10	10		21	W	1			Do.
	6	11	35	20		E	1			Do.
	6	11	5		2·5	E		1		
	6	11	15		24	E		1		At top.
	6	11	50		38	W	1			Do.
	7	10	9	25		E	1			
	7	10	0	18		E	2			
	7	9	53		13	E	1			At top.
	8	10	0	31		E		Slight		Do.
	8	9	15		8	E	Slight	1		To red at base ; to violet at top.
	8	9	0		12	E		1		At top.
	8	10	28	48		W	2			
	9	9	0	53·5		E	Slight			At top.
	9	9	2	29		E	1·5			Do.
	9	8	49	67		W	Slight			Do.
	9	9	4	63·5		E	1			Do.
	9	9	20	17		E		1		Do.
	9	9	12		12	W		0·5		At base.
	9	9	9	9		W	1			At top.
	11	10	31	Equator		E		1		Do.
	11	10	26		2	E		1		Do.
	12	9	12	64		E	Slight			At base.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1927.		H.	M.	°	°		A.	A.	A.	
October	12	9	14	26		E	0·5			At base.
	12	9	25		2	E	1			Do.
	12	9	0		12	E	0·5			Do.
	16	11	53	24		E	1·5			At top.
	16	11	46	17		W	2	1		To red at base ; to violet at top.
	17	10	4		30	W	1			At base.
	17	10	1	Equator.		W	0·5			At top.
	18	10	15	59		W	1			Do
	19	9	44		26	E	1·5			At base.
	19	9	39		17	W	1			At top.
	19	9	36	33		W	1			Do.
	22	10	25		42	E		1		Do.
	22	9	55		22	W		1		At base.
	23	9	3	17		E	1			Do.
	23	9	20		42	W	2			At top.
	24	8	51		5	W	1			Do.
	24	8	44	37		W	1			Do.
	26	9	11	24		E	1			At base.
	26	9	2		9	W		1		Do.
	29	9	18	15		E	1			Do.
	29	9	5		23	W	Slight			At top.
	30	10	49		25	W	0·5			Do.
	31	9	25		17	E	Slight			At base.
November	2	10	10	79		E		Slight		At base.
	2	10	13	68		W		0·5		Do.
	3	9	15	60		E	0·5			
	9	10	12		3	E	1			At base.
	13	9	20	35		E	0·5			Do.
	13	9	38	7		E		0·5		At top.
	14	10	39	45		E	Slight			At base.
	14	10	36	54		W	0·5			At top.
	15	10	1	13		E	1·5			At base.
	15	10	1	15		E		0·5		At top.
	15	9	30		17·5	W	1			Do.
	16	9	24	27		E	Slight			
	16	9	27		20	E	0·5			At base.
	16	9	20		63	W		Slight		No prominence.
	16	9	6		20	W	1			At top.
	16	9	6		18	W		1		
	19	10	23		16	W	1			At base.
	19	9	13	28		W	1			At top.
	21	9	10		11	W		0·5		At base.
	21	9	0	61		W	1·5			At top.
	22	10	9	25		E		0·5		Do.
	22	9	58		75	W	Slight			Do.
	22	9	55		41	W	0·5			Do.
	22	9	52		16	W	0·5			Do.
	22	9	36		10	W		1		At base.
	22	9	39		6	W	1			At top.
	22	9	35	7		W	1			Do.
	23	9	0	58		E		0·5		At base.
	23	9	12	27		E		1		At top.
	23	9	7	3		W	1			Do.
	24	9	58	4		W	0·5			
	26	9	35	42		E		Slight		At top.
	26	10	37	9		E	1	1		To violet at top ; to red at base.
	26	9	41	5		E	1			At base.
	26	9	41	4		E		2		Throughout the height of the prominence between +3° to 5° E.
	26	9	41	2		E	2	3		At the top most of part of the prominence whose base is between +3° to 5° E.
	26	9	48		22	E	0·5			At top.
	26	9	48		25	E		1		Do.
	26	10	54		60	E		1		On a floating speck.
	26	9	9	13		W		0·5		At top.



The western hemisphere shows a slight preponderance over the eastern in areas, the percentage east being 49·68; in numbers the percentage east is 50·71.

Thanks are due to the co-operating observatories for the photographs supplied by them.

THE OBSERVATORY, KODAIKANAL,
23rd August 1928.

T. ROYDS,
Director, Kodaikanal and Madras Observatories.

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Kodaikanal Observatory.

BULLETIN No. LXXXV. 85

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE FIRST HALF OF THE YEAR 1928.

In pursuance of the programme of work adopted since 1st January 1923 under the auspices of the International Astronomical Union, all observatories taking spectroheliograms of the sun have been asked to co-operate with the Kodaikanal Observatory by supplying copies of their photographs on those days when the Kodaikanal records are imperfect or wanting. In response to our requirements for the first half of the year 1928, the Mount Wilson Observatory supplied prominence plates for 10 days and Hα disc plates for 11 days; Meudon Observatory supplied K_3 disc plates for 9 days and Hα disc plates for 19 days; and the Pitch Hill Observatory (Mr. Evershed's) at Ewhurst, Surrey, England, supplied 10 prominence plates and 5 Hα disc plates.

When only incomplete or imperfect photographs for any day are available from more than one observatory, the best photograph is chosen as representing the solar activity of that day after weighting it according to its quality, and the remaining photographs are ignored.

The mean daily areas and numbers of prominences during the half-year are given below. The means are corrected for incomplete or imperfect observations, the total of 179 days for which plates were available being reduced to $167\frac{3}{4}$ effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North	3·71	10·72
South	3·45	8·72
Total ...	7·16	19·44

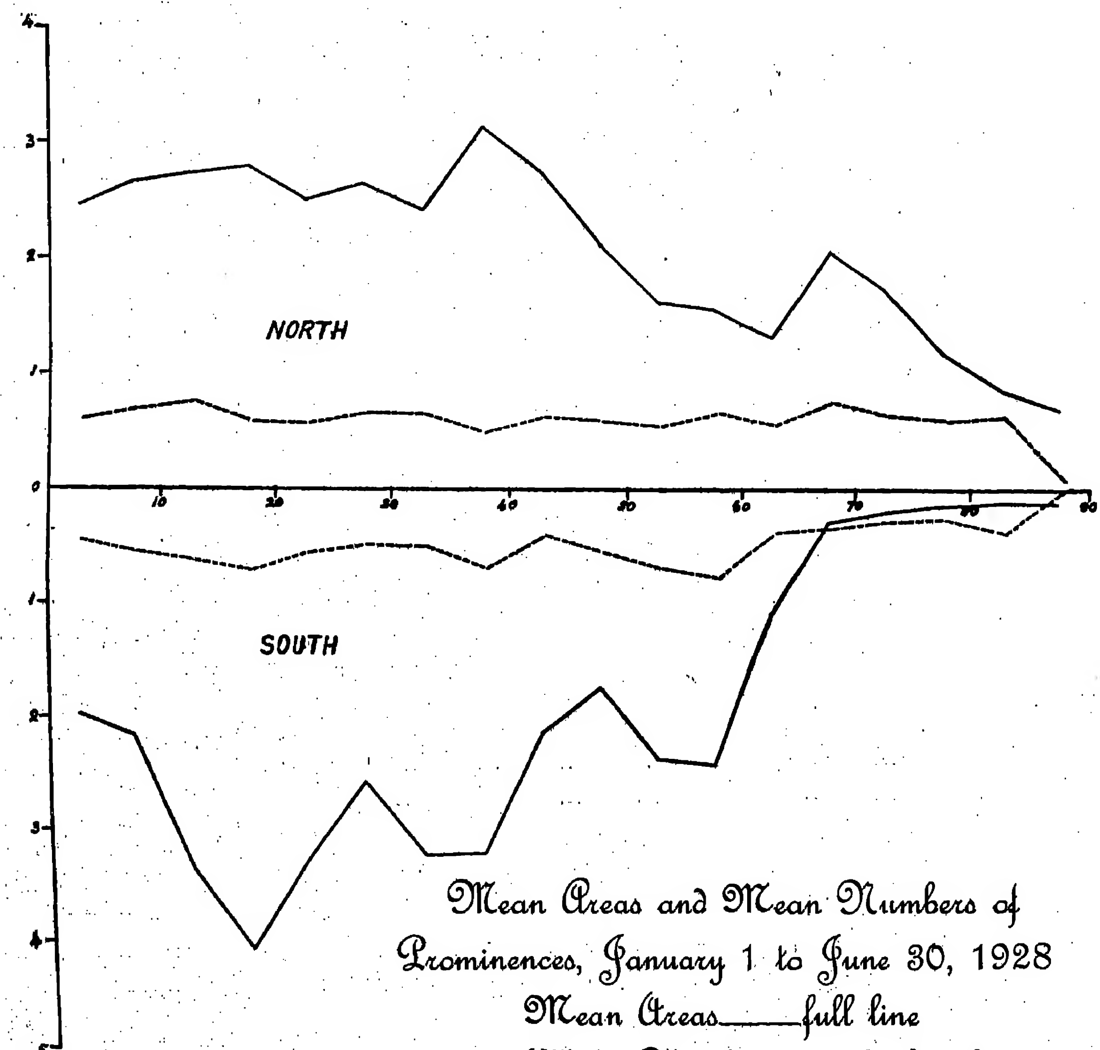
Compared with the previous half-year areas show an increase of 30 per cent and numbers an increase of only 2 per cent, and the predominance of activity in the northern hemisphere is maintained.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 163 days of observation being counted as 158 effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North (Kodaikanal photographs only)	3·80	10·83
South (do.)	3·50	8·80
Total ...	7·30	19·63

The distribution of prominences in latitude is represented in the following diagram, in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude. The

ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line. The activity in high latitudes has subsided in the southern hemisphere. There are peaks near 40° and 70° in the northern hemisphere and near 20°, 35° and 55° in the southern. Prominence areas in the equatorial regions have exhibited a marked increase compared with the previous half-year.



Mean Areas and Mean Numbers of Prominences, January 1 to June 30, 1928
Mean Areas ——— full line
Mean Numbers - - - - broken line

The monthly, quarterly and half-yearly areas and numbers, and the mean height and mean extent of the prominences on photographs from all the co-operating observatories are given in Table I. The unit of area is 1 square minute of arc. The mean height is derived by adding together the greatest heights reached by individual prominences and dividing by the total number of prominences observed; the mean extent is derived by adding together the lengths of the base on the chromosphere of individual prominences and dividing by the total number of prominences.

TABLE I.—ABSTRACT FOR THE FIRST HALF OF 1928.

Months.	Number of days (effective).	Areas.	Numbers.	Daily Means. Areas.	Daily Means. Numbers.	Mean height.	Mean extent.
1928.						″	°
January	27	157·7	489	5·8	18·1	39·1	5·00
February	26¾	171·5	513	6·4	19·1	38·7	5·42
March	30	251·8	690	8·4	23·0	40·4	5·94
April	29¾	229·2	628	7·7	21·1	42·0	7·59
May	31	259·2	550	8·4	17·7	41·2	9·80
June	23¼	132·6	387	5·7	16·6	37·8	7·95
First quarter	83¾	581·0	1,692	6·9	20·2	39·5	5·65
Second quarter	84	621·0	1,565	7·4	18·6	40·7	8·45
First half-year	167¾	1,202·0	3,257	7·2	19·4	40·1	7·00

Distribution east and west of the Sun's axis.

During the half-year both areas and numbers showed an excess at the east limb compared with the west limb as will be seen from the following table :—

1928 January to June.	East.	West.	Percentage East.
Total number observed	1,644	1,614	50·5
Total areas in square minutes	623·7	578·3	51·9

Metallic prominences.

Fifty-two metallic prominences were observed during the half-year. Their details are given below :—

TABLE II.—LIST OF METALLIC PROMINENCES OBSERVED AT KODAIKANAL, JANUARY TO JUNE 1928.

Date.		Hour I.S.T.		Base.	Latitude. North.	Latitude. South.	Limb.	Height.	Lines.
1928.		H.	M.	°	°	°		″	
January	3	9	20	3	11·5		W	15	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5276·0, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	9	9	2	4		18	W	25	4924·1, 5016, b_4, b_3, b_2, b_1, 5276·0, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	10	10	17	3		18·5	W	30	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5316·8, 5363·0, D_2, D_1.
	14	10	25	1	6·5		W	20	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5361·8, 5337·0, 5363·0, D_2, D_1.
	16	9	30	10	16		E	25	4924·1, 5018·6, 5198·0, 5233·2, 5269·8, 5276·0, 5283·7, 5316·8, 5328·0, 5371·7, D_2, D_1, 6677, 7065.

Date.		Hour I.S.T.		Base.	Latitude.		Limb.	Height.	Lines.
					North.	South.			
1928.		H.	M.	°	°	°		″	
January	18	9	30	4	5		W	10	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5233·0, 5270·6, 5316·8, D_2, D_1, 6677, 7065.
	19	10	24	1		10·5	W	10	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·0, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	23	9	48	3		21·5	W	10	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5269·8, 5276·0, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
February	1	11	7	6	3		W	15	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5208·8, 5270·7, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065. Form seen in most lines.
	9	9	59		13		E	5	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·0, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	12	9	15	4	16		E	20	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276 0, 5316·8, 5363·0, D_2, D_1, 6677, 7065. Form seen in many lines.
	14	9	33	2	21		E	5	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5276·2, 5316·8, D_2, D_1, 6677, 7065.
	15	9	50	1	15·5		E	5	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·0, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	19	9	5	3		16·5	E	10	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	21	9	33	3		34	E	35	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5316·8, D_2, D_1.
	25	10	10	1	15·5		W	5	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·0, 5316·8, 5363·0, D_2, D_1.
	26	9	15	2		7	E	15	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·0, 5316·8, 5363·0, D_2, D_1, 6677, 7065. Displacement seen in many of the lines.
	27	8	47	4		22	W	15	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	29	9	37	4		12	E	5	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·0, 5316·8, 5363·0, D_2, D_1.
March	4	9	30	2		6	W	5	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·0, 5316·8, D_2, D_1, 6677, 7065.
	7	8	34	3		13·5	W	20	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 7065.
	8	8	47	2		18	W	20	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5276·2, 5316·8, D_2, D_1.
	9	9	0			16	E	10	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065. Displacement seen in D's and b's also.
	10	8	24	1	19·5		E	10	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5276·2, 5316·8, D_2, D_1, 6677.
	11	8	44	2	21		E	15	5018·6, b_4, b_3, b_2, b_1, 5316·8, D_2, D_1.
	13	9	4	2	11		E	10	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	14	8	44	3	6·5		W	10	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	20	8	38	2	17		W	5	b_4, b_3, b_2, b_1, 5316·8, D_2, D_1.
	23	9	13	4		10	E	10	5018·6, b_4, b_3, b_2, b_1, 5316·8, D_2, D_1, 6677, 7065.
	24	9	56	1	11·5		W	5	b_4, b_3, b_2, b_1, D_2, D_1. Faintly reversed.
	25	9	0	2		15	W	10	5018·6, b_4, b_3, b_2, b_1, 5276·2, 5316·8, D_2, D_1.
	26	8	55	2	11		W	20	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5227·3, 5266·8, 5269·9, 5276·2, 5316·8, 5363, D_2, D_1.
	28	9	10	5	9·5		E	15	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5197·4, 5208·7, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 7065.
April	2	8	42	2		13	E	10	4924·1, 5016, 1518·6, b_4, b_3, b_2, b_1, 5234·8, 5269·8, 5263·6, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	6	8	56	2		13	W	10	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5270, 5276·2, 5316·8, 5063·0, D_2, D_1, 6677, 7065.
	11	10	0			19	W	5	5018·6, b_4, b_3, b_2, b_1, D_2, D_1, 6677.
	12	9	40	2	25		W		b_4, b_3, b_2, b_1, D_2, D_1, 6677.
	22	9	22	3	11·5		W	15	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1. Form seen in b's and D's.
	27	9	30	2	9		E	10	5018·6, b_4, b_3, b_2, b_1, 5316·8, D_2, D_1, 6677, 7065.
May	6	8	33	3	15·5		E	20	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1.
	7	8	33	2	16		E	15	5018·6, b_4, b_3, b_2, b_1, 5276·2, 5316·8, 5363·0, D_2, D_1.

Date.		Hour I.S.T.		Base.	Latitude.		Limb.	Height.	Lines.
					North.	South.			
1928.		H.	M.	°	°	°		″	
May	12	10	2	4		12	W	15	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5316·8, 5276·2, D_2, D_1, 6677, 7065.
	13	9	0	4		16	W	15	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	13	9	25	3		12·5	E	10	5018·6, b_4, b_3, b_2, b_1 5676·2, 5316·8, D_2, D_1, 6677.
	14	8	32	9		14·5	W	10	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	15	8	32	4		13	W	10	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	21	8	50	3	14·5		E	10	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0. D_2, D_1, 6677, 7065.
	26	8	50	5		13·5	E	15	4924·1, 5016, 5018·6. b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	27	8	48	5		10·5	E	15	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
June	3	9	45	5	11·5		W	20	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, D_2, D_1, 6677, 7065.
	23	12	0	4	19		E		4924·1, 5018·6, 5234·9, 5269·8, 5266·2, 5284·2, 5316·8, 5328·2, 5363·0, 5371·7.
	27	10	5	8	32		E		b_4, b_3, b_2, b_1, D_2, D_1.

The distribution of the metallic prominences was as follows :—

	1°—10°	11°—20°	21°—30°	31°—40°	Mean latitude.	Extreme latitudes.
North	6	17	3	1	14°·2	3° and 32°
South	3	19	2	1	15°·0	6° and 34°

Twenty-five were on the east limb and 27 on the west limb.

Displacements of the hydrogen lines.

Particulars of the displacements observed in the chromosphere and prominences are given in the following table :—

TABLE III.—DISPLACEMENTS OF HYDROGEN LINES.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1928.		H.	M.	°	°		A.	A.	A.	
January	1	9	32	54		E	0·5			At base.
	1	9	35	6		E	0·5			Do.
	1	9	16	30		W	0·5			At top.
	2	9	21	87		E		0·5		
	2	9	15	5		E	1			At base.
	2	9	26		44	E	Slight			At top.
	3	9	30		16	E	1	0·5		To red at base ; to violet at top.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1928.		H.	M.	°	°		A.	A.	A.	
January	3	9	20	9		W	1			At top.
	3	9	14	18		W		1		At base.
	3	9	12	30		W	0·5			
	4	9	0		53	E		0·5		At top.
	4	8	50	16		W	0·5			Do.
	8	11	23		17	W	1			Do.
	9	8	58	48		E		0·5		At base.
	9	9	2		19	W		0·5		Do.
	9	9	2		16	W	1			At top.
	10	10	17		19	W	1	2		Do.
	11	10	57		13	E	1			Do.
	11	10	46	31		W		0·5		Do.
	14	11	0	82·5		E	0·5			At base.
	14	10	41		8	W	1			At top.
	14	10	19	7		W	Slight			Do.
	15	9	9	83·5		E	Slight			
	15	9	12	15		E	2·5	1		To red at top ; to violet at base.
	15	9	58		46	E	Slight			At base.
	15	9	48		4	W		0·5		Do.
	15	9	34	4		W	1			At top.
	15	9	22	53		W	Slight			
	16	9	6	34		E		Slight		
	16	9	30	23		E		2		At top.
	16	9	30	17		E	2	1·5		To red at base; to violet at top.
	16	9	30	16		E			1	
	16	9	40	14		E	3			At base.
	16	9	30	13		E		1		Do.
	16	9	12		17	E	1			Do.
	16	8	14		27	E			1	Do.
	17	11	18		76·5	W		1		At top.
	17	11	28		18	W		3		Do.
	18	9	30	4		W	1·5			Do.
	18	9	30	7		W	1	0·5		To red at top ; to violet at base.
	19	10	0	30		E		0·5		At top.
	19	9	52	5·5		E		1		Do.
	19	9	47		37	E		1		Do.
	19	9	47		41	E		Slight		Do.
	19	10	19		14	W	3			Do.
	19	10	19		9	W			1	Do.
	19	10	19		10	W		1		At base.
	19	10	19		7	W		1		Do.
	20	9	18	26		E	1			At top.
	20	9	39	7		E	0·5			At base.
	20	9	27	47		W	0·5			At top.
	21	10	24	8		E	1			At base.
	21	10	34		4	E		1·5		At top.
	21	10	37		14	E	Slight			Do.
	21	10	37		30	E	1			At base.
	21	10	40		67·5	E		1		At top.
	21	10	19		15	W	0·5			Do.
	21	10	5	30		W	Slight			Do.
	23	9	14	39		E	Slight			Do.
	23	9	35		20	E	3	1·5		To red at base ; to violet at top.
	24	9	12		17	E	3			At base.
	24	9	12		17	E	1·5	1		At middle.
	24	9	16		35	E	Slight.			At base.
	24	9	27	24		W	1			Do.
	25	8	59	67·5		E	1			At top.
	25	9	17	12		E		0·5		At base.
	25	9	22		10	E	5			Do.
	25	9	22		16	E	5	1		To red at top ; to violet at middle.
	25	9	6	13		W	1			At top.
	26	9	43	42·5		E		Slight		Do.
	26	9	28		9	E	4			Do.
	26	9	28		14	E	1			Do.
	26	9	58	6		W	2			Do.
	27	9	26	18		E	1			Do.
	27	9	31	68 5		W	Slight			

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways	
1928.		H.	M.	°	°		A.	A.	A.	
January	30	9	28	46·5		E	0·5			At top.
	30	9	32	21		W	Slight			At base.
	31	9	25	36·5		E	Slight			At top.
	31	9	21	10		E		1		At base.
	31	9	58		19	E	0·5			At top.
	31	9	55		61	E	0·5			Do.
	31	10	14	2		W		1		At base.
	31	9	20	4		W	1			
	31	10	10	6·5		W	3			At top.
	31	10	14	8		W		1		At base.
February	1	10	56		18	E		0·5		
	1	11	7	3		W	2	1		To red at top; to violet at base.
	1	11	7	8		W	2			At top.
	5	8	55	50·5		E	Slight			Do.
	5	8	59	21		W	1	0·5		To red at top; to violet at base.
	7	9	7	18		E	1·5			At top.
	7	10	15		18	W	1			Do.
	7	9	12		12	W		1		At base.
	9	10	19	25		E	1			At top.
	9	10	19	20		E		Slight		Do.
	9	9	59	13		E			1	Do.
	9	10	30		26	W		1		Over whole prominence.
	10	11	9		38·5	W	1			At top.
	11	10	0		78·5	W	1			In chromosphere.
	11	9	32		17	W	0·5			Do.
	12	9	2	78·5		E		0·5		At base.
	12	9	0	73		E	1			At top.
	12	9	29	43·5		E	0·5			At base.
	12	9	15	21		E	0·5	1		To red at base; to violet at top.
	12	9	22	18		E		0·5		At base.
	12	9	31		14·5	E	1			At base; the displacement extends through 5° along the base.
	12	9	28		38·5	W		0·5		At base.
	12	9	25		22	W	0·5			At top.
	12	9	6	24		W	1			Do.
	13	9	10	28		E		0·5		At base.
	13	9	7	18		E	1	0·5		To red at top; to violet at base.
	13	9	12	33		W	0·5			At top.
	13	9	14	66		W	Slight			
	14	9	15	22		E	1	2·5		To red at top; to violet at base.
	14	9	33	21		E	2			At top.
	16	9	37	6·5		E		1		On a floating prominence.
	16	10	7	81·5		W	1			At top.
	17	9	34	7		E		1		Do.
	17	9	32		14	E		1		Do.
	17	9	29		16·5	E		1		Do.
	17	9	41		44·5	E	0·5			At base
	18	9	55		18·5	E	2·5	2		Over the whole prominence.
	18	10	1		12	E		1		At top; the displacement extends through 4°.
	18	10	1		15	E		2		At top.
	18	10	9		18·5	E		5		At top of floating cloud.
	19	9	16	23		E	0·5			At base.
	19	9	6		7	E	1			At top
	19	9	5		18	E	1			At base.
	19	8	58	27		W		0·5		At top.
	20	9	2	59		E	1			At base.
	20	9	54		2	E	1			Do.
	20	9	12		48·5	E	0·5			Do.
	21	9	8	32·5		E	1			Do.
	21	9	26		12	E	1	1		At top.
	21	9	31		34	E	2			The displaced portion is detached and the displacement extends 3° on it.
	21	9	19		26	W	0·5			At top.
	21	9	14	48·5		W		Slight		
	21	9	12	78·5		W		Slight		

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet .	Both ways.	
1928.		H.	M.	°	°		A.	A.	A.	
February	22	9	30	60		E		Slight		At base.
	22	10	27		17·5	E	1			Do.
	22	10	33		36·5	E	Slight	2		At top.
	22	9	56	9		W	Slight			Do.
	23	9	53		12	E		1		Do.
	23	9	51		16	E		1		
	23	9	45		37	E	1			At top.
	24	9	7	23		W	0·5			Do.
	24	9	1	82·5		W		Slight		
	25	10	20		18	W	1			At top.
	25	10	10	15·5		W	3			Do.
	25	9	50	18		W		2		At base.
	26	9	20	1		E		1		At top.
	26	9	15		7	E	1	1·5		To red at base ; to violet at top.
	26	10	2		7	E	6	4		To red at top ; to violet at base.
	26	9	50		21	W		0·5		At top.
	26	10	3		8	W	2			Do.
	26	10	0	17		W		2		
	27	9	6	76		E		Slight		
	27	8	47		21	W	2	2·5		To red at base ; to violet at top. Ghost seen 6-A to red.
	27	9	14		12	W	0·5			At top.
	28	9	17	51·5		E	0·5	Slight		To red at top ; to violet at base.
	28	9	15	39·5		E		Slight		At base.
	28	9	28		25	W	2	2·5		To red at top ; to violet at base.
	28	9	22	1		W	0·5			At top.
	29	9	50		26	W	1			Do.
March	1	9	49	52·5		E		0·5		At top.
	1	9	36		29	E		Slight		At base.
	1	9	55		25	W	1			At top.
	1	10	28	17		W	1			Do.
	1	10	30	24		W		Slight		At base.
	1	10	33	82·5		W	1			At top.
	3	9	40		66	E	0·5			Do.
	3	10	4		31	W	1			Do.
	4	8	42	78·5		E		Slight		At base.
	4	8	46	73·5		E	Slight			
	4	8	38	44·5		E		Slight		
	4	9	3	20		E	0·5			At base.
	4	1	36	18		E	0·5			
	4	8	35		1	E		0·5		
	4	9	6		40·5	E		1		At base.
	4	8	52		54·5	E		0·5		At top.
	4	9	22		5	W	1			Do.
	4	8	56		5	W		1		At base.
	4	8	44	75·5		W	0·5			At top.
	5	8	55		6	E	1	1·5		To red at base ; to violet at top.
	5	9	18		10	E	1			At base.
	5	9	5		21	W	0·5			At top.
	5	9	12		6	W		0·5		At base.
	5	8	57		3	W	1			At top.
	6	8	36		1	E	2			At base.
	6	8	38		11	E		0·5		At top.
	6	8	33		37·5	W	1			Do.
	6	8	28		11	W	1			Do.
	6	8	48		5	W	1			Do.
	6	8	23	13		W	0·5			Do.
	6	8	23	18		W		Slight		
	7	8	19	29		E	Slight			
	7	8	45		33·5	E		1		At base.
	7	8	34		12	W	1			At top.
	7	8	28		1	W		Slight		
	7	8	26	7		W		1		At base.
	7	8	22	66		W		Slight		
	8	8	39	79·5		E		0·5		Do.

Date.	Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
			North.	South.		Red.	Violet.	Both ways.	
1928.	H.	M.	°	°		A.	A.	A.	
March 8	8	34	8		E	1			At base.
8	9	2		53·5	E		1		At top.
8	9	14		37·5	W	1·5			Do.
8	8	45	7		W		0·5		
8	8	43	40·5		W		Slight		
8	8	41	74		W		Slight		
9	9	20	19		E	0·5			At base.
9	9	5	10		E		1		At top.
9	9	25		8	E	0·5			At base.
9	9	0		16	E	1	1·5		To red at base ; to violet at top.
9	9	27		23	E	1			At base.
9	9	17		66	E		Slight		
9	9	14		82	W		Slight		No prominence.
9	9	12		73·5	W	0·5			At top.
9	8	50		11	W	1			Do.
9	8	47	21		W	Slight			
9	8	44	83		W		Slight		
10	8	26	35·5		E		Slight		
10	8	24	19·5		E	1	0·5		To red at top ; to violet at base.
10	8	33		11	W	1			At top.
10	8	53		5	W		0·5		At base.
11	8	38	37·5		E		Slight		
11	8	44	21		E		0·5		At top.
11	9	3	4		E		1		Do.
11	8	40		3	W		Slight		
12	8	33	77		E	0·5			
12	8	30	24		E		0·5		
12	9	5		2	E	0·5			At base.
12	9	9		12	E	0·5			Do.
12	9	8	21		W	0·5			At top.
12	8	36	65		W	0·5			Do.
13	8	44	72·5		E	0·5			Do.
13	8	40	62·5		E		0·5		No prominence.
13	8	38	30		E	0·5			At top.
13	9	4	11		E	1·5	1		To red at base ; to violet at top.
13	9	30	8		E		2·5		At top.
13	9	32		19	E	2			At base.
13	8	46	77		W		Slight		
14	8	33	20		E		1		At base.
14	8	31	10		E	1·5	1		To red at top ; to violet at base.
14	8	44	7		W	1·5	0·5		Do. do.
15	8	43	67		E		Slight		At base.
15	8	53	12		E		1		At top.
15	8	45		30	E	1			At base.
15	9	4		34·5	E		1·5		At top.
15	8	51		7	W	1			Do.
15	8	51		4	W		0·5		At base.
15	8	44	63		W		Slight		Do.
16	8	48	74·5		E		Slight		
16	8	40	21		E	1			At top.
16	9	10	21		E		1		Do.
16	9	0		10	E			1	
16	8	54		10	W	1	0·5		To red at top ; to violet at base.
16	8	52	12		W	2·5	1·5		Do. do.
17	9	32	69		E	0·5			At top.
17	8	50	35·5		E	0·5			Do.
17	10	10		2	E		0·5		Do.
17	10	12		9	E		1		Do.
17	9	57		10·5	W	2·5	2		To red at top ; to violet at base.
17	9	52	1		W	1			At top.
17	9	50	16		W	1·5	0·5		To red at top ; to violet at base.
18	8	42	35·5		E		2		At base.
18	8	57	35·5		E	1			Do.
18	8	54		7	E		0·5		At top.
18	8	50		17	E		1		Do.
18	9	18		38·5	E	0·5			At base.
18	9	20		83	E	Slight			Do.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1928.		H.	M.	°	°		A.	A.	A.	
March	18	9	4		22	W	1			At top.
	18	9	4		18	W	1			Do.
	19	9	45		38·5	E	1			At base.
	19	8	48		38·5	W		0·5		
	19	11	0		22	W		1·5		At base.
	19	11	0		20	W	2·5			At top.
	19	8	42		14	W	1			Do.
	19	8	42		10	W		0·5		At base.
	19	8	31	82·5		W		Slight		
	20	8	30	66		E	Slight			
	20	8	26	9		E		0·5		
	20	8	58		10	E		1		At top.
	20	9	0		37·5	E	0·5			At base.
	20	9	0		40·5	E		1		At top.
	20	8	48		76	W		0·5		At base.
	20	8	42		22	W	0·5			At top.
	20	8	38	17		W	1			Do.
	21	9	8	11·5		E		Slight		At base, extends through 3°.
	21	9	4		36·5	E		1		At top.
	21	8	56		66	W	1			At base.
	22	8	52	67		E		Slight		
	22	8	50	58·5		E		Slight		
	22	8	48	30		E	2			At top, extends through 4° from 28° to 32°.
	22	8	45	13		E	0·5			At top.
	22	9	32		34·5	E	1			At base.
	22	9	19		39·5	W		0·5		Do.
	22	9	16		17	W		Slight		
	23	9	10	5		E		1		At top.
	23	9	13		12	E	1			At base.
	23	9	15		19	E	2	1·5		To red at base; to violet at top.
	23	9	16		23	E		1·5		At top.
	23	9	3		24	W		Slight		
	23	8	54	50·5		W		Slight		
	24	9	40		14·5	E			Slight	At top, extends through 1°.
	24	9	55	12		W		1		At top.
	25	8	39	78		E		0·5		At base.
	25	9	6		7	E		0·5		At top.
	25	9	2		67	W		1		Do.
	25	8	56		21	W	1			Do.
	25	9	0		18	W		0·5		At base.
	25	8	54		12	W	1			At top.
	25	8	48	6		W	1			Do.
	25	8	42	54·5		W	Slight			Do.
	26	8	44	67		E	Slight			
	26	8	40	43·5		E		0·5		At base.
	26	8	37	20		E	1			At top.
	26	9	3		32·5	W	1			Do.
	26	8	55	10		W	3			Do.
	26	8	55	12		W		2·5		At base.
	26	8	55	16		W	1			At top.
	27	8	44	72·5		E	1·5	1		To red at top; to violet at base.
	27	9	57	54·5		E	Slight			
	27	8	41	49·5		E		1		At base.
	27	9	53	30		E	Slight			At top.
	27	10	13	23		E	1			At base.
	27	9	48	7		E		0·5		Do.
	27	9	48	4		E	0·5			At top.
	27	9	6		69	W	1			
	27	9	2		36·5	W	1			
	27	10	9	Equator.		W		Slight		
	27	10	6	26		W		Slight		
	28	9	8	9		E		1		At base.
	28	9	8	7		E		1		Do.
	28	9	8	6		E	3			Do.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1928.		H.	M.	°	°		A.	A.	A.	
March	29	8	59	9		E		0·5		At base.
	31	9	21		37·5	W		1		In chromosphere.
April	1	9	12	16		E	Slight			At top.
	1	9	33		30	E	1·5	1		Do.
	2	8	27	31·5		E		Slight		At base.
	2	8	42		13	E	1·5	1		To red at base ; to violet at top.
	2	8	42		18	E		1		At top.
	2	8	34		62·5	W	Slight			
	2	8	32	77·5		W		Slight		
	3	8	58	14		E	1			At top.
	3	9	44		16	E	1	1		To red at top ; to violet at base.
	3	9	13	66		W	1·5			At top.
	4	9	12	17		E	1			Do.
	4	9	44		12	E		1		At base.
	4	11	19		24	W	4			Do.
	4	9	32		23	W		1·5		At base ; the displacement extends through 2° from 22° to 24°.
	4	11	8		21	W		2		
	4	11	23		19	W		2		At top.
	4	9	25	25		W	1·5			Do.
	5	8	36	60·5		E		Slight		
	5	8	58	31		E	1			At base.
	5	9	2		13	E		1		At top.
	5	8	36		25·5	W	1	1		To red at top ; to violet at base ; the displacement extends through 1° from 25° to 26°.
	5	8	44	25		W	0·5			At top.
	5	8	39	43·5		W	1·5			Do.
	6	8	28	33		E	Slight			
	6	8	28	12		E	1			At top.
	6	8	56		13	W	1	1·5		To red at top ; to violet at base.
	6	8	58		13	W	3	3·5		Do.
	6	9	15		10	W	1			At top.
	6	8	36	34		W	0·5			Do.
	7	8	48	19		E	1·5			Do.
	7	9	15		13	E		1		Do.
	7	9	15		17	E	2·5	2		To red at base; to violet at top.
	7	9	1	3		W		Slight		
	7	8	51	78·5		W		Slight		
	8	8	45	14		E		1·5		At base.
	8	8	41	11		E	1·5			At top.
	9	9	55		3	E		0·5		At base.
	9	9	53		8	E		1		At top.
	10	9	23	14		E	2·5	1·5		To red at top; to violet at base.
	10	9	27		7	E		3·5		At base.
	10	8	46		7	E		2		Do.
	10	9	27		9	E	3			Do.
	10	9	30		24	W	0·5			At top.
	10	9	11	7		W	1·5			Do.
	10	9	0	12		W	1·5			Do.
	10	9	3	17		W		1		At base.
	10	9	3	25		W	1			At top.
	11	9	48	79·5		E	0·5			Do.
	11	10	5	22		E	0·5			At base.
	11	10	0		19	W	1	0·5		To red at top; to violet at base.
	11	8	53		7	W	1			At base.
	11	8	53		4	W	0·5			At top.
	11	9	50	35		W	0·5			Do.
	12	9	17	71		E	0·5			Do.
	12	9	15	57·5		E	Slight			Do.
	12	9	10	10		E		0·5		At base.
	12	10	2		30	E	1·5			At top.
	12	10	5		53·5	E	Slight			At base.
	12	9	55		66	W	1			At top.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1928.		H.	M.	°	°		A.	A.	A.	
April	12	9	45		20	W		0·5		At base.
	12	9	45		17	W	1			At top.
	12	9	31	24		W	0·5			Do.
	12	9	35	26		W	0·5			At base.
	13	8	49	63·5		E		Slight		
	13	9	0		71	W		Slight		
	13	8	52	38·5		W	1			At top.
	14	9	10	71		E		1		At base.
	14	9	5	51·5		E	1			At base, extends over 1° from 51° to 52°.
	14	9	1	30		E	Slight			At top.
	14	8	56		2	E		0·5		At base.
	14	9	37		13	E	1			At top.
	14	9	43		57·5	E	1			At base.
	14	9	32		53·5	W		1		Do.
	14	9	21	15		W		1		At top.
	14	9	18	23		W	1	1		Both at base.
	15	9	12	47·5		E	1·5			At top.
	15	9	9	37		E		Slight		At base.
	15	9	9	34		E	Slight			At top.
	15	9	0	6		E	1			At base.
	15	9	50		37	W	1			At top.
	15	9	50		32	W	Slight	0·5		Both at base.
	15	10	53		20	W	0·5			At base.
	15	10	53		15	W	1			At top.
	15	9	44		14	W	2			Do.
	15	10	53		13	W	2			Do.
	15	10	53		12	W		1		At base.
	15	10	53		10	W		1		Do.
	15	9	35	29		W	1·5			Do.
	15	9	32	56·5		W	1	1		Both at base.
	16	11	24	47		E		0·5		At base.
	16	11	50		16	W	1			At top.
	16	11	43	37		W	1			Do.
	16	11	43	40		W	0·5			Do.
	17	8	51	32		E		0·5		Do.
	17	8	48	21		E	1			At base.
	17	8	43	1		E	Slight			Do.
	17	9	26		19	E		Slight		At top.
	17	9	22		66·5	W	1			Do.
	17	9	17		40	W		Slight		Do.
	17	9	17		38	W	Slight			At top.
	17	9	10	11		W		1		At base.
	18	9	40		15	E	1			At top.
	19	9	0	13		E	Slight			At base.
	19	8	57		2	E	1·5			At top.
	19	9	40		15	E	1			Do.
	19	9	40		19	E	2			Do.
	19	9	40		20	E		1		At base.
	19	9	46		47	E	1·5			At top.
	19	9	28		15	W		0·5		At base.
	19	9	25	6		W		0·5		At top.
	19	9	25	10		W	1			Do.
	19	9	15	58·5		W	1	0·5		Both at base.
	20	9	20	26		E		1		At top.
	20	9	22	6		E	1			At base.
	20	9	6	39		W		0·5		
	21	9	23	9		E	1			At top.
	21	9	23	4		E		1		Do.
	21	9	55	35		W		1		At top, extending from the prominence between 18° to 33°.
	22	8	40	11		E		1·5		At top ; the displacement extends over 4° from 9° to 13°.
	22	9	15	6		E	1			At base.
	22	8	50	11		W		0·5		At top.
	22	8	50	15		W	0·5			Do.
	22	8	43	20		W		0·5		Do.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1928.		H.	M.	°	°		A.	A.	A.	
April	22	8	44	36		W		Slight		At base.
	23	9	32	8		E	1			Do.
	23	10	3		8	E	1			Do.
	23	10	3		11	E		1·5		At top.
	23	8	3	6		W	1			Do.
	23	9	22	14		W	1·5	1		To red at top ; to violet at base.
	23	9	20	29		W		Slight		
	24	8	55	73·5		E	1·5			At top.
	24	8	45	17		E	1			Do.
	24	9	25		4	E	Slight			At base.
	24	9	25		6	E		Slight		Do.
	24	9	29		15	E	0·5			At top.
	24	9	29		17	E	1			Do.
	24	9	17		58·5	W		Slight		At base.
	24	9	17		56·5	W	Slight			At top.
	24	9	13		38	W		1		At base.
	24	9	13		34	W	0·5			Do.
	24	9	3	34		W		0·5		Do.
	24	9	2	42		W	0·5			Do.
	25	10	25	42		E	Slight			Do.
	25	8	55	13		E	0·5			
	25	9	26	6		E		0·5		At base.
	25	9	22		2	E	2·5			At top.
	25	9	22		5	E	2			At top, extends over 2° from 4° to 6°.
	25	9	22		6	E		2		At top, extends over 2° from 5° to 7°.
	25	9	22		10	E		1·5		At base.
	25	9	10		15	E	2			At top.
	26	10	11	62·5		E	Slight			
	26	9	50	23·5		E	1			At top, extends over 1° from 23° to 24°.
	26	9	50	26·5		E		1		At top, extends over 1° from 26° to 27°.
	26	9	34	18		E	2			In chromosphere.
	26	9	46	13		E		2·5		At top.
	26	9	30		21	E	2			Throughout height.
	26	9	23		38	E		Slight		At top.
	27	8	56	23		E		1		Do.
	27	8	54	3		E	1			At base.
	27	9	20	9		E	1	1·5		To red at base ; to violet at top.
	27	9	4		6	W		2		At base.
	27	9	0	65·5		W		Slight		
	28	10	0	7		E		Slight		At top.
	28	9	35		62·5	W		1		At base.
	29	8	51		7	E	1			At top.
	29	9	2		10	E		2·5		At base.
	29	8	50		12	E		0·5		Do.
	29	8	57		16	E	0·5			At top.
	29	9	3		18	W	1			Do.
	29	8	56	17		W	1			Do.
	29	8	55	43		W	Slight			Do.
	29	9	8	79·5		W			0·5	
	29	8	54	85·5		W		0·5		At base.
	30	8	44	5		E	1·5	3		To red at base ; to violet at top.
	30	8	48		11	E		1		At top.
	30	9	11		16	E		3		Do.
	30	9	7		20	E	2·5	4		To red at base ; to violet at top.
	30	8	35		74·5	W	1			At top.
	30	8	32		17	W	1·5			Do.
	30	9	0		14	W		1		At base.
	30	8	27	49		W		Slight		
May	1	10	19	19		E		1		At base.
	1	9	6		10	E	2·5			At top.
	1	9	6		14	E	2			At top, extends over 2° from 13° to 15°.
	1	10	56		14	E	3	1		To red at top, to violet at base ; extends over 2° from 13° to 15°.
	1	9	6		16	E		3·5		At base.
	1	10	56		16	E		1·5		Do.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1928.		H.	M.	°	°		A.	A.	A.	
May	1	10	40		20	W		0·5		At base.
	1	10	40		15	W	0·5			At top.
	2	9	57		13	E		1·5		Do.
	2	9	14		13	E	2·5			At base.
	2	9	20		12·5	W	0·5			At top.
	3	9	14	5		E	Slight			At base.
	3	8	42		10	E	1			Do.
	3	9	43		16	E	Slight			Do.
	3	8	50		19	W	Slight			
	3	9	35	6		W	Slight			At base.
	3	9	34	16·5		W		1·5		At top, extends over 1° from 16° to 17°.
	3	9	34	20		W	2			At top, extends over 2° from 19° to 21°.
	4	9	5	26		E	0·5			At top.
	4	9	39	16·5		E		1		At top, extends over 3° from 15° to 18°.
	4	9	13		12	E	1			At base.
	4	9	18		28	E	1			Do.
	4	9	18		35	E	1·5			At base, extends over 6° from 32° to 38°.
	4	9	29		29	W		Slight		At base.
	4	9	11	7		W	1			At top.
	4	9	9	43		W	1			Do.
	5	10	18	16		E		1		Do.
	5	10	18	13		E	0·5			
	5	9	30	6		E		2		At the middle of the prominence.
	5	9	30	3		E		1		At top.
	5	9	59	5		W		1		Do.
	5	9	48	77·5		W		1		Do.
	6	8	28	29		E		1		Do.
	6	8	33	18		E		1		Do.
	6	8	33	14		E	1			At base.
	6	8	45	5		E		1		At top.
	6	9	10		16	E	0·5			At base.
	6	9	12		53	E	0·5			Do.
	6	9	40	11		W	0·5			At top.
	7	8	33	16		E	1·5	0·5		To red at base ; to violet at top.
	7	8	50		12	E		0·5		At top.
	7	8	40		15	W	0·5			Do.
	9	10	7	20		E		1		Do.
	9	10	45		42	E		Slight		At base.
	9	10	3		35	W	1			At top.
	9	9	52	7		W	1·5			Do.
	9	9	52	8		W		1		At base.
	9	9	52	9		W	1			Do.
	9	9	50	23		W		Slight		Do.
	9	9	47	68		W	Slight			Do.
	10	9	25		19	E	Slight			At top.
	10	9	14		1	W	0·5			At base.
	10	9	14	6		W	1	1		Both at top.
	10	9	14	8		W	1			At top.
	10	9	14	9		W	Slight			Do.
	10	9	5	49		W	Slight			Do.
	11	8	25	84		E		Slight		
	11	8	22	10		E		0·5		At top.
	11	8	34		7	E	Slight			At base.
	11	8	36		10	W		1		Do.
	11	8	36		7	W	1			At top.
	11	8	28	87		W	0·5			Do.
	12	10	2		12	W	3·5	2·5		To red at top ; to violet at base.
	12	9	48		11	W		1		At base.
	13	8	37	22		E		0·5		Do.
	13	8	35	15		E	Slight			At top.
	13	9	25		13	E	1	0·5		To red at base ; to violet at top.
	13	9	0		20	W	1			At top.
	13	9	0		16	W		2·5		Do.
	13	9	0		14	W	3			At base.
	13	8	48		12	W			0·5	

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1928.		H.	M.	°	°		A.	A.	A.	
May	13	9	5		4	W		1		At top, extends over 6° from 1° to 7°.
	13	8	42	28		W	1			At top.
	14	9	5	64		E		Slight		At base.
	14	8	45	14		E	Slight			Do.
	14	8	41		8	E	1			Do.
	14	8	32		18·5	W	3·5	4		To red at base ; to violet at top ; extends over 1° from 18° to 19°.
	14	8	32		18	W	1			At top.
	14	8	32		15	W	1			At top, extends over 2° from 14° to 16°.
	14	8	32		11	W	1	0·5		To red at top ; to violet at base.
	15	8	50	17		E		0·5		At top.
	15	8	50	9		E	0·5			At base.
	15	8	55		13	E	0·5			Do.
	15	9	18		20	W	3	7		To red at top ; to violet at base.
	15	9	18		18	W	1·5			At top.
	15	9	18		12	W	1			At base.
	15	8	38	67		W	0·5			At top.
	16	8	55	81·5		E		Slight		
	16	10	5	31		E	Slight			At base.
	16	8	47		21	W	4	1		To red at top ; to violet at base.
	16	9	20	30		W		0·5		At base.
	17	8	44	14		E	Slight			At top.
	17	8	54		24	E	Slight			At base.
	18	8	52	10		E	Slight	0·5		Both at base.
	18	9	28		71	W	1			At top.
	18	9	15		18	W	1			Do.
	18	9	11	4		W	1			Do.
	18	9	10	14		W	1			Do.
	18	9	5	56		W	Slight			Do.
	19	8	58	19		E	0·5			At base.
	19	8	53		82	W		1		Do.
	19	8	51		31	W		Slight		Do.
	19	8	49	14		W	1	0·5		To red at top ; to violet at base.
	19	8	39	45		W	Slight			At top.
	20	10	17	15		E		0·5		
	20	10	34		48	E	0·5			At top.
	20	10	32		83·5	W		Slight		
	20	10	25		17	W	0·5	0·5		To red at top ; to violet at base.
	20	11	1		1	W	0·5			At top.
	20	10	22	5		W	1			Do.
	20	10	20	14		W	1			Do.
	21	8	50	14		E	2	1		To red at base ; to violet at top.
	21	8	45	9		E	1			At base.
	21	8	42		2	E	0·5			
	21	8	25		9	E	1			At base.
	21	8	40		13	E		1		At top.
	21	8	36		84·5	W	Slight			Do.
	21	8	33		62	W		Slight		At base.
	21	8	30		9	W	0·5			At top.
	22	8	47	31		E	Slight			At base.
	22	8	50		41	E	0·5			Do.
	22	8	32	40		W	1			At top.
	23	8	34	26		E		0·5		Do.
	23	8	50	43		W	0·5			Do.
	24	8	52		15	E	Slight			
	24	9	0		40	E		1		At top.
	25	8	37	59		E		Slight		
	25	7	59	7		E		0·5		At base.
	25	8	33		11	E	1			Do.
	25	8	31		18	E	Slight			Do.
	25	8	25		84	W	0·5			
	26	8	12	46		E		Slight		
	26	8	27	28		E	Slight			At top.
	26	8	50		12	E	2	2·5		To red at base ; to violet at top.
	26	8	50		19	E	6			At top.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1928.		H.	M.	°	°		A.	A.	A.	
May	26	8	35		25	E	Slight			At base.
	27	8	48		10	E	1·5	2		To red at base ; to violet at top.
	27	8	48		18	E	6	2		To red at top ; to violet at base.
	28	9	34	10		E	Slight			At base.
	28	9	24		16	E		2		At top.
	28	9	27		24	E		1		Do.
	29	8	35	79		E		Slight		At base.
	29	8	40	17		E		1		At top.
	29	8	46		22	E	1			At base.
	29	8	27		54	W		Slight		Do.
	29	8	20	23		W	1	0·5		To red at top ; to violet at base.
	29	8	33	87		W	Slight			At base.
	30	8	14		16	E		1		At top.
	30	8	11		32	W		Slight		At base.
	30	8	7		13	W		Slight		
	31	8	19	34		E		Slight		
	31	8	28		18	E		Slight		
	31	8	24	40		W	0·5			
June	1	11	5		12	W	0·5			
	2	8	20	14		E	1	4		To red at base ; to violet at top.
	2	8	35		4	W	0·5			At top.
	2	8	16	7		W		Slight		At base.
	2	8	16	9		W	0·5			At top.
	2	8	14	74		W	0·5			Do.
	3	9	28	11		W	1·5	2		To red at top ; to violet at base.
	3	9	48	13		W	3			At top.
	13	11	12		20	E		1		Do.
	13	11	5		64	W	0·5			Do.
	13	11	2	19		W	Slight			
	17	8	42	24		E	1			At top.
	17	8	42	23		E		0·5		At base.
	17	8	47	14		E		1		Do.
	18	9	12	34		E	1·5			At top.
	18	9	12	26		E		1		At base.
	18	9	22		48	E	0·5			Do.
	19	8	53	66		E	Slight			At top.
	19	9	6	14		E	Slight			At base.
	20	9	33		42	W	0·5			At top.
	20	9	30		20	W	1			Do.
	20	9	27	14		W	Slight			Do.
	22	11	36	17		E	Slight			Do.
	22	11	40		9	E		3		Do.
	22	11	40		12	E	1			At base.
	22	11	45		16	E	1			Do.
	23	11	56	22		E	2			
	23	11	56	20		E	4			
	23	11	56	17		E			0·5	
	23	11	48		6	E		Slight		At top.
	23	11	35		29	E			3	
	23	11	27		64	E	1			At base.
	23	12	39		9	W	1	Slight		To violet at top.
	24	8	46	13		E	1			At base.
	24	9	6		17	W	0·5			At top.
	24	9	8	7		W	3			Do.
	24	9	5	35		W		0·5		At base.
	27	10	5	32		E	1	1·5		To red at top.
	28	9	40	11		E		1		At base.
	28	9	40	9		E	1·5			At top.
	28	9	29		60	W	0·5			Do.
	28	9	26		21	W	Slight			At base.
	28	9	26		15	W	Slight			At top.
	29	9	23		21·5	W	1			Do.
	29	9	17	20		W	1			Do.
	30	9	40		16	E		Slight		Do.

The total number of displacements was 786 as against 252 in the previous half-year and their distribution was as follows :—

Latitude.	North.	South.
Equator	1 ...	...
1°—30°	264	295
31°—60°	80	62
61°—90°	59	25
Total	1 403	382

East limb	434
West limb	352
Total	786

Four hundred and thirty-eight displacements were towards the red, 338 towards the violet and 10 both ways simultaneously.

Reversals and displacements on the Sun's disc.

Five hundred and eighty-six bright reversals of the Hα line, 541 dark reversals of D_3 line and 253 displacements of the Hα line were observed during the half-year. Their distribution is given below :—

	North.	South.	East.	West.
Bright reversals of Hα	269	317	313	273
Dark reversals of D_3	247	294	294	247
Displacements of Hα	120	133	160	93

One hundred and eighty-four displacements were towards the red, 67 towards the violet and 2 both ways simultaneously.

Prominences projected on the disc as absorption markings.

Photographs of the Sun's disc in Hα light were available from Kodaikanal and the co-operating observatories for a total of 181 days, which were counted as 174¾ effective days. The mean daily areas of Hα absorption markings (corrected for foreshortening) in millionths of the Sun's visible hemisphere and their mean daily numbers are given below :—

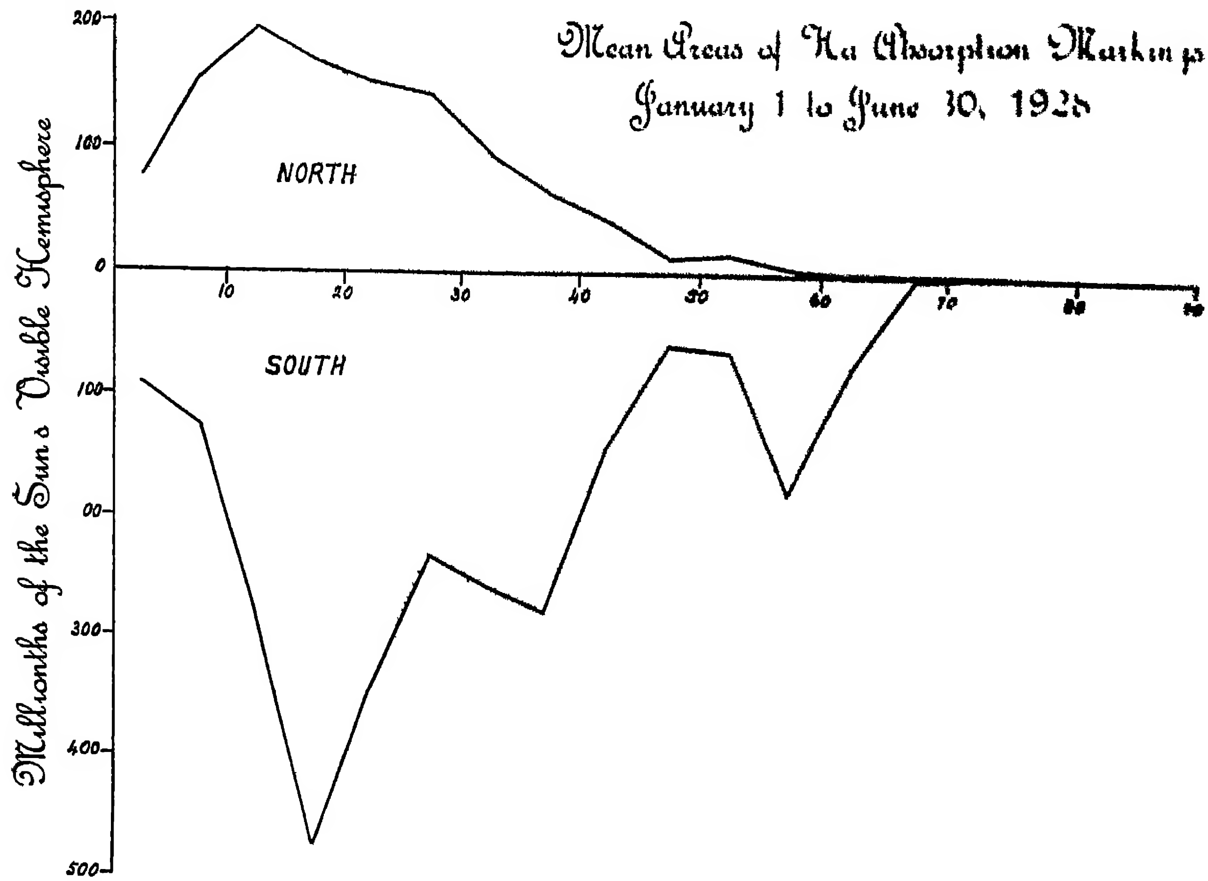
	Mean daily areas.	Mean daily numbers.
North	1,132	11·2
South	2,608	18·4
Total	3,740	2·96

The above totals show an increase of about 8 per cent in areas and an increase of 3 per cent in numbers compared with the previous half-year. There is a decrease in the northern hemisphere which is more than counterbalanced by the increase in the southern and resulting in a considerable preponderance of activity in the southern hemisphere in contrast to the northern preponderance of prominences at the limb.

For comparison with bulletins issued prior to the [illegible] Kodaikanal photographs alone are also given 163 days [illegible]

	[illegible]	[illegible]
North (Kodaikanal photographs only)	[illegible]	[illegible]
South (do)	[illegible]	[illegible]
Total	[illegible]	[illegible]

The distribution of the mean daily areas in latitude is shown in the following diagram [illegible] maximum of activity still persists within the zone 10 to 20 and the [illegible] peak of activity [illegible] southern hemisphere



There is an excess of activity in the western hemisphere both in areas and numbers, the percentage east being 49 03 for areas and 48 23 for numbers

Thanks are due to the co operating observatories for the photographs supplied by them.

THE OBSERVATORY KODAIKANAL
7th March 1929

T ROYDS,
Director Kodaikanal and Madras Observatories

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Kodaikanal Observatory.

BULLETIN No. LXXXVI.

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE SECOND HALF OF THE YEAR 1928.

In pursuance of the programme of work adopted since 1st January 1923 under the auspices of the International Astronomical Union, all observatories taking spectroheliograms of the Sun have been asked to co-operate with the Kodaikanal Observatory by supplying copies of their photographs on those days when the Kodaikanal records are imperfect or wanting. In response to our requirements for the second half of the year 1928, the Mount Wilson Observatory supplied prominence plates for 55 days and Hα disc plates for 33 days; Meudon Observatory supplied K_3 disc plates for 18 days and Hα disc plates for 30 days; and the Pitch Hill Observatory (Mr. Evershed's) at Ewhurst, Surrey, England, supplied nine prominence plates and eleven Hα disc plates.

When only incomplete or imperfect photographs for any day are available from more than one observatory, the best photograph is chosen as representing the solar activity of that day after weighting it according to its quality, and the remaining photographs are ignored.

The mean daily areas and numbers of prominences during the half-year are given below. The means are corrected for incomplete or imperfect observations, the total of 176 days for which plates were available being reduced to 149 effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North	3·52	9·03
South	3·32	8·22
Total ...	6·84	17 25

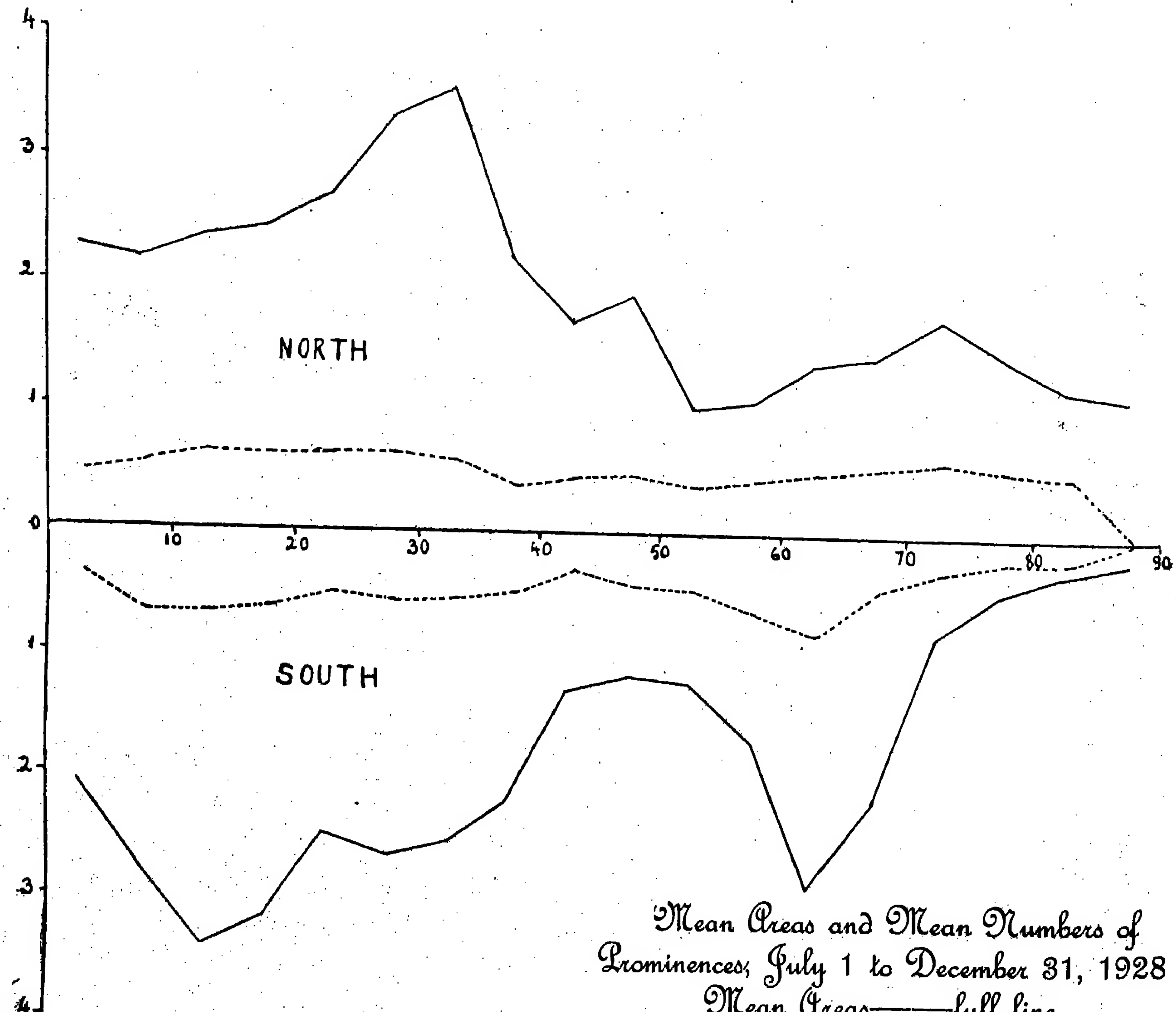
Compared with the previous half-year areas show a decrease of about 4·5 per cent and numbers a decrease of about 11·3 per cent, and the predominance of activity in the northern hemisphere is still maintained.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 144 days of observation being counted as 122 effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North (Kodaikanal photographs only)	3·66	9·66
South (do.)	3·47	8·73
Total ...	7·13	18·39

The distribution of prominences in latitude is represented in the following diagram, in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude. The

ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line. Compared with the previous half-year the diagram shows a slight change in the distribution of activity in the various zones. The peaks of activity in the higher latitudes have moved about 5° towards the poles, whereas those in the low latitudes have moved 5° towards the equator.



Mean Areas and Mean Numbers of Prominences, July 1 to December 31, 1928
Mean Areas——full line
Mean Numbers- - - -broken line

The monthly, quarterly and half-yearly areas and numbers, and the mean height and mean extent of the prominences on photographs from all co-operating observatories are given in Table I. The unit of area is 1 square minute of arc. The mean height is derived by adding together the greatest heights reached by individual prominences and dividing by the total number of prominences observed; the mean extent is derived by adding together the lengths of the base on the chromosphere of individual prominences and dividing by the total number of prominences.

TABLE I.—ABSTRACT FOR THE SECOND HALF OF 1928.

Months.	Number of days (effective).	Areas.	Numbers.	Daily Means.		Mean height.	Mean extent.
				Areas.	Numbers.		
1928.						"	°
July	25¾	177·1	451	6·9	17·5	43·9	7·99
August	25¼	177·8	435	7·0	17·2	42·4	6·47
September	28¼	224·7	503	8·0	17·8	38·2	7·03
October	26¼	171·8	416	6·5	15·9	40·8	7·17
November	18	129·3	308	7·2	17·1	46·3	6·45
December	25½	137·2	446	5·4	17·5	37·0	4·93
Third quarter	79¼	579·6	1,389	7·3	17·5	41·4	7·17
Fourth quarter	69¾	438·3	1,170	6·3	16·8	49·4	6·13
Second half-year	149	1,017·9	2,559	6·8	17·2	45·0	6·69

Distribution east and west of the Sun's axis.

Unlike that in the previous half-year, both areas and numbers showed an excess at the west limb compared with the east limb as will be seen from the following table :—

1928 July to December.	East.	West.	Percentage East.
Total number observed	1,240	1,309	48·6
Total areas in square minutes	4,989	5,195	49·0

Metallic prominences.

Twenty-seven metallic prominences were observed during the half-year. Their details are given below :—

TABLE II.—LIST OF METALLIC PROMINENCES OBSERVED AT KODAIKANAL, JULY TO DECEMBER 1928.

Date.		Hour I.S.T.		Base.	Latitude.		Limb.	Height.	Lines.
					North.	South			
1928.		H.	M.	°	°	°		"	
July	11	10	49	6		20	E	15	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	24	8	32	2		17	W		5018·6, b_4, b_3, b_2, b_1, 5316·8, D_2, D_1, 6677.
August	10	9	14	3	25·5		E	25	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	27	12	12	4		23	W	20	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1.

Date.		Hour I.S.T.	Base.	Latitude. North.	Latitude. South.	Limb.	Height.	Lines.
1928.		H. M.	°	°	°		″	
September	4	9 47			20	W	10	b_4, b_3, b_2, b_1, D_2, D_1, 6677, 7065.
	5	9 8	3		17·5	W	15	b_4, b_3, b_2, b_1, D_2, D_1.
	6	9 15		15		E		4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	18	8 50	4	17		E	20	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	18	8 44	5		19 5	E	10	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	19	9 10	2	20		W	15	b_4, b_3, b_2, b_1, D_2, D_1.
	24	8 45	4		15	W	20	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677.
	25	9 10	2		15	W	15	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5270·0, 5276·2, 5316·8, D_2, D_1, 6677.
	26	9 43	1		19·5	E	15	b_4, b_3, b_2, b_1, D_2, D_1.
	30	9 35	2		30	W	20	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
October	3	9 46	3		16·5	W	15	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5316·8, D_2, D_1, 6677.
	7	9 12	3	14·5		E	15	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5316·8, 5363·0, D_2, D_1.
	13	8 34	3		15·5	E	15	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5316·8, D_2, D_1.
	28	10 10	1	15·5		W	15	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5276·2, 5363·0, 5371·8, D_2, D_1, 6677, 7065.
	29	10 30	6	14		W	5	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	30	12 0	4	16		W		b_4, b_3, b_2, b_1, D_2, D_1, 7065.
November	3	10 2	2		15	E	10	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
December	6	10 6			11	E	15	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5269·8, 5316·8, D_2, D_1, 6677, 7065.
	6	9 50	1	20·5		E	15	4924·1, 5018·6, b_4, b_3, b_2, b_1, D_2, D_1.
	10	9 12	4	20		E	15	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	11	8 52	4	19		E	10	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5276·2, 5316·8, D_2, D_1, 6677.
	24	8 57	4	9		W	10	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, D_2, D_1, 7065.
	31	9 33	2	13		E	10	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5233, 5316·8, D_2, D_1, 6677.

The distribution of metallic prominences was as follows :—

	1°—10°	11°—20°	21°—30°	Mean latitude.	Extreme latitudes.
North	1	11	1	16·8	9 and 25·5
South	1	11	2	17·1	5 and 30

Fourteen were on the east limb and 13 on the west limb.

Displacements of the hydrogen lines.

Particulars of the displacements observed in the chromosphere and prominences are given in the following table :—

TABLE III.—DISPLACEMENTS OF HYDROGEN LINES.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1928.		H.	M.	°	°		A.	A.	A.	
July	3	9	29	7		W		0·5		At base.
	4	8	38		14	E	1·5	1		To red at base ; to violet at top.
	5	9	54	12		E		1·5		At base.
	5	10	22	3		E	1			At top.
	5	10	22		1	E		1		At base.
	5	10	25		13	E	Slight			At top.
	5	10	25		15	E		0·5		At base.
	5	8	50		23	W		0·5		
	5	8	48		15	W	1			At top.
	5	10	9	27		W	Slight			Do.
	6	11	40		8	E	0·5	0·5		To red at base ; to violet at top.
	8	9	8		7	W	1			At top.
	10	9	7	17		E		0·5		Do.
	10	8	50		78·5	W	0·5			Do.
	10	8	45	20		W	1			Do.
	11	10	46		18	E	1·5	2·5		To red at base ; to violet at top.
	11	10	50		20	E	5·0			At base.
	11	10	40		28	W		0·5		Do.
	15	8	16	85		E		Slight		
	15	8	40	33		E		1		At top.
	15	8	40	30		E	1			At base.
	15	8	42	10		E	0·5			Do.
	15	8	22		24	W		0·5		
	15	8	19	4		W		Slight		
	19	12	32		19	E		0·5		At base.
	20	14	10	15		W	1			At top.
	21	8	20	12		E		1		Do.
	21	8	30	14		E	0·5			At base.
	21	10	26		12	W	1			At top.
	21	10	24		7	W		0·5		At base.
	21	8	15	11		W		0·5		Do.
	22	8	50	17		E		0·5		Do.
	22	9	5		61·5	W		1		At top.
	22	8	55	12		W	1			Do.
	22	8	53	29		W	0·5			Do.
	23	12	47		16	W	1·5	1		To red at top ; to violet at base.
	24	9	35		47	W	0·5			At top.
	24	8	32		17	W	0·5			At top ; extends over 2° from 16° to 18°.
	24	8	32		13	W	1	1·5		To red at base ; to violet at top.
	25	9	18	16		E	1			At top.
	25	9	25		19	E		1·5		At top ; extends over 4° from 17° to 21°.
	25	9	25		24·5	E	1			At base ; extends over 3° from 23° to 26°.
	26	9	24		28	W		1		At top.
	26	9	54	16		W	2			Do.
	26	9	20	19		W	1			Do.
	26	9	6	21·5		W		1		Do.
	29	8	33	71		E		0·5		At base.
	29	8	36		8	E	1			Do.
	29	8	29		18	W		0·5		Do.
	29	8	27	13		W	Slight			At top.
	30	8	28		14	E	1			At base.
	30	8	30		34	E		1		At top.
	30	8	33		81	E		Slight		
	30	8	23		79·5	W	0·5			At top.
	30	8	20	22		W		0·5		
	31	9	2	13		E	1			At top.
	31	10	45		23	W	2·5	1·5		

Date.		Hour I.S.T.		Latitude. North.	Latitude. South.	Limb.	Displacement. Red.	Displacement. Violet.	Displacement. Both ways.	Remarks.
1928.		H.	M.	°	°		A.	A.	A.	
August	4	8	50	10		E		1		At top.
	4	10	47	26		W		Slight		At base.
	4	10	55	33		W		2		At top.
	5	9	34	29		E	1			Do.
	5	9	44	6		W		0·5		At base.
	5	9	42	37		W		Slight		
	10	9	14	25		E	1			At base.
	10	9	26	6		E	1			Do.
	10	9	8		11	W	1			At top.
	11	9	0	16		E	0·5			At base.
	14	11	0		14·5	E		0·5		At top; extends over 3° from 13° to 16°.
	14	10	45	17		W	4·5			At top; extends over 2° from 16° to 18°.
	15	11	45		19	E	1·5			At top.
	18	9	23	24		E	1			At base.
	18	9	25	11		E		1·5		At top.
	18	9	25	8		E	0·5			At base.
	18	9	35	5		E	1			Do.
	22	10	33	16		E	1·5			At top.
	22	10	27		10·5	E	1·5			Do.
	22	10	45		30·5	W	0·5			Do.
	23	9	35		19·5	W		1		Do.
	24	8	54	4		E	0·5			At base.
	24	8	56		5	E	Slight			Do.
	27	11	32	15		E	0·5			Do.
	27	12	12		29	W	4			At top.
	27	11	24		13	W	1·5			At top; extends over 2° from 12° to 14°.
	27	11	24		14	W		1		At base.
	29	9	5	23		E	1·5			At base; extends over 2° from 22° to 24°.
	29	8	58		14·5	E		1·5		At top.
	30	9	25	19·5		W	Slight			At base.
September	2	9	20		25	E	2			At base; extends over 6° from 22° to 28°.
	2	8	50		24	W	1			At base; extends over 2° from 23° to 25°.
	4	9	47		20	W	1	4		To red at top; to violet at base.
	5	9	5		17·5	W	1·5			At base; extends over 3° from 16° to 19°.
	5	9	5		12·5	W	1			At base; extends over 3° from 11° to 14°.
	6	9	15	15		E	1·5	1		Both at base.
	6	10	30	11·5		W	Slight			At base.
	6	10	30	18·5		W	Do.			Do.
	7	9	1	30·5		E	Do.			Do.
	7	9	2	30		E	3	1·5		
	7	9	42		19	E	Slight			At base.
	7	9	18		11	W	1			At top.
	8	10	5	38		E			Slight	
	8	9	30		62·5	W		1		At top.
	8	9	25		53·5	W	Slight			At base.
	9	9	0	14		E		1		Do.
	10	11	27		8	E		Slight		At top.
	12	9	20		82·5	E		Do.		At base.
	12	9	9	30		W	1			At top.
	15	10	16	15		E		1		Do.
	15	10	39		35·5	W	1			Do.
	16	9	14		17	W	1			Do.
	16	9	7	16		W	1			Do.
	17	9	30	13		E	1			At base.
	17	8	45	2		W	1			At top; extends over 2° from 1° to 3°.
	18	8	52	25		E	0·5			At top.
	18	8	50	18		E	2	1·5		To red at base; to violet at top.
	18	9	12	13		E		1		At top.
	18	8	50	7		E	1			Do.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1928.		H.	M.	°	°		A	A.	A.	
September	18	8	44		17	E		0·5		At top.
	18	8	44		20	E	1·5			At base.
	18	9	1	17		W	1	0·5		To red at top; to violet at base.
	18	8	38	23		W	1			At top.
	19	9	13	11		W		Slight		At base.
	20	9	25	13		E			Slight	
	20	9	0	12		W	2			At top.
	21	9	37	18·5		E		Slight		At base.
	21	9	40	1		E		Do.		Do.
	21	9	45		15	E			Slight	
	23	10	46	78·5		E	1			At top.
	23	10	58		56·5	W	0·5			Do.
	24	9	5		12	E		0·5		At base.
	24	8	45		15	W	1	0·5		To red at top; to violet at base.
	25	9	10		15	W	0·5	1		Do.
	25	9	28		12	W	1			At top.
	26	9	45	0·5		E	Slight	1		To red at top; to violet at base.
	26	9	43		19	E	1			At base.
	26	9	16		23·5	W	3			At top.
	26	9	15		21·5	W	Slight			Do.
	27	9	31		15	W	2			At top; extends over 2° from 14° to 16°.
	27	9	30		12·5	W		1·5		At top.
	29	9	20		24	W		1·5		At top; extends over 2° from 23° to 25°.
	29	8	55	60		W		Slight		At top.
	30	9	14		30	W			2·5	At base; extends over 2° from 29° to 31°.
	30	9	35		30	W	3	8		Extends over 2° from 29° to 31°.
	30	9	14		27	W	6			At base.
	30	9	14		20·5	W	5·5			At top; extends over 3° from 19° to 22°.
	30	9	9		11	W	0·5			At base; extends over 2° from 10° to 12°.
	30	9	8		9	W			Slight	At; base extends over 2° from 8° to 10°.
	30	9	0	7·5		W	1·5			At base.
October	1	9	29	56·5		E		1		At top.
	1	9	3	18		E	1	2·5		To violet at top; to red at base.
	1	9	8	15		E		1		At top.
	1	9	25		24	W	0·5			Do.
	1	9	7	17		W	0·5			Do.
	1	9	18	83		E	0·5			Do.
	3	9	27	34·5		E	1·5			At base.
	3	8	56		19	W		1·5		At top; extends over 2° from 18° to 20°.
	3	9	46		19	W	3	3·5		Do.
	3	8	55		16·5	W	5·5			At top; extends over 3° from 15° to 18°.
		8	50	1		W	1			At top; extends over 2° from 0° to 2°.
		9	14	11		E		1		At top.
	5	8	52	Equator.		W	Slight			
	6	9	1	15		E	1·5			At base.
	6	9	2	9		E	1			Do.
	6	8	45		2·5	E	2			At middle; extends over 5° from 0° to 5°.
	6	9	5		9	E		1·5		At top.
	7	8	49	70		E		0·5		At base.
	7	9	12	18		E		2		At top.
	7	9	9	5		E	0·5			Do.
	7	9	17		33	E	0·5			At base.
	8	9	2	26		W	Slight			At top.
	12	10	24		8·5	W	Do.			At base.
	13	8	32	13		E	1			At top.
	13	8	34		15	E	1·5	1		To violet at top; to red at base.
	24	10	14		40	W		Slight		At base.
	24	9	55	18·5		W	1			At top.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North	South		Red.	Violet.	Both ways.	
1928.		H.	M.	°	°		A.	A.	A.	
October	25	10	4		23	W		1		At base.
	25	9	54		0·5	W		2		Do
	28	10	0	15		W	2	1		To red at top; to violet at base; extends over 2° from 14° to 16°.
	28	9	31	25		W	1·5			At top.
	29	10	6	19		E		0·5		Do.
	29	10	5	15·5		E		2		At top.
	29	10	30	15		W		1		At base.
	29	10	30	17		W			0·5	At top.
	29	10	30	19		W		1		Do.
	30	11	8	14		E		1		Do.
	30	11	17	13		E	1			At base.
	30	11	18	18		E		1		
	30	10	55		44	E		Slight		At top.
	30	11	45		25	W		1		Do.
	30	12	0	15·5		W	1·5			At top; extends over 3° from 14° to 17°.
	30	12	0	15		W		2		At base.
	30	12	0	18		W	1			At top.
	30	11	31	75·5		W	1			At base.
	31	9	42		35	W	1			At top.
	31	10	40		29	W	1			Do.
November	2	9	15		14	E	1·5	2		To violet at base.
	2	9	17		26	E	Slight			At base.
	3	10	27		4	E	1			At top.
	3	9	58		8	E		1		Do.
	3	9	58		9	E	1			At base.
	3	9	58		13	E	1·5			Do.
	3	9	58		20	E		1		At top.
	3	10	0		13	E	3	1		To violet at base.
	3	9	47		46	E		1		At top.
	8	11	25		23·5	E			Slight	Do.
	8	11	38		8	W	Slight			Do.
	8	11	30	4		W	1·5			Do.
	17	10	50	5		E		1		Do.
	18	8	57		58	W		1		Do.
	19	8	58	25		E		0·5		Do.
	25	9	22	50		E		Slight		Do.
	25	9	14		29	E		1		Do.
	25	9	12		55	E		1		Do.
	28	10	8	25		W	1			Do.
December	2	9	24		49	W		Slight		At base.
	6	9	42	58		E		1		At top.
	6	9	50	20·5		E	2	0·5		To red at top; to violet at base.
	6	10	5		11	E			1	
	6	9	28	28		W		Slight		
	10	8	52	35		E		Do.		At base.
	10	9	12	19		E	2·5			Do.
	10	9	17	15		E	1			Do.
	10	9	26	15		E	2			Do.
	11	8	52	19		E	1·5	1		To red at base; to violet at top.
	12	14	52	4		W	1			At base.
	13	11	57	30		E	1			Do.
	13	11	58	27		E	1			At top.
	13	11	58	26		E	2			Do.
	14	10	53		14	W		1		At base.
	15	10	51	36		E	1			Do.
	15	11	10		52	E	1			Do.
	15	10	38		14	W		1		At top.
	15	10	32		10	W	1			Do.
	15	10	26	6		W		1		Do.
	16	9	19		32	W	0·5			At base.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1928.		H.	M.	°	°		A.	A.	A.	
December	16	9	16	43		W	1			At top.
	18	9	3	18		E	0·5			Do.
	18	9	7	1		E	1			Do.
	18	9	9		10	E		1		Do.
	19	8	56		10	W	1			Do.
	19	8	50	67		W		Slight		
	20	11	22		46	E		Do.		At top
	20	11	45		22	W	1			Do.
	21	9	14		13	E	1			At base.
	21	9	8		16	W		1		At top.
	21	9	4	21		W	Slight			
	22	9	55	39		E		1		At top.
	22	9	49		6	E	1			At base.
	22	9	49		9	E	1			At top.
	23	9	7	6		E	Slight			At base.
	23	8	53	67		W		Slight		Do.
	24	9	11	35		E	0·5			Do.
	24	9	6		21	W	1·5			At top.
	24	8	57	17		W	0·5			Do.
	31	9	32	13		E	0·5	1		At base.
	31	9	12	56		W	1			Do.
	31	8	57	63		W	Slight			
	31	8	52	78·5		W			Slight	

The total number of displacements was 281 as against 786 in the previous half-year and their distribution was as follows :—

Latitude.		North.	South
Equator ...	1	...	...
1°—30° ...	...	119	113
31°—60° ...	...	17	17
61°—90° ...	...	9	5
Total ...	1	145	135

East limb ...	144
West limb ...	137
Total ...	281

Reversals and displacements on the Sun's disc.

Three hundred and twenty-nine bright reversals of the Hα line, 300 dark reversals of D_3 line and 99 displacements of the Hα line were observed during the half-year. Their distribution is given below :—

	North.	South.	East.	West.
Bright reversals of Hα	184	145	170	159
Dark reversals of D_3	170	130	155	145
Displacements of Hα	67	32	52	47

Sixty-eight displacements were towards the red, 29 towards the violet and 2 both ways simultaneously.

Eruptive prominence.

The highest prominence ever recorded at Kodaikanal was photographed during the period under review by the Director, Dr. T. Royds, on the 19th November 1928 and had reached a height of 20′′9 or 910,000 kms. when clouds intervened. The successive photographs of this remarkable prominence showed the whole mass to be rising from the Sun's surface with an accelerating speed. The velocities in the lower parts of the prominence were 60—70 kms. and in the higher parts 100—170 kms. and increased with time.

Prominences projected on the disc as absorption markings.

Photographs of the Sun's disc in Hα light were available from Kodaikanal and the co-operating observatories for a total of 176 days, which were counted as 169¾ effective days. The mean daily areas of Hα absorption markings (corrected for foreshortening) in millionths of the Sun's visible hemisphere and their mean daily numbers are given below :—

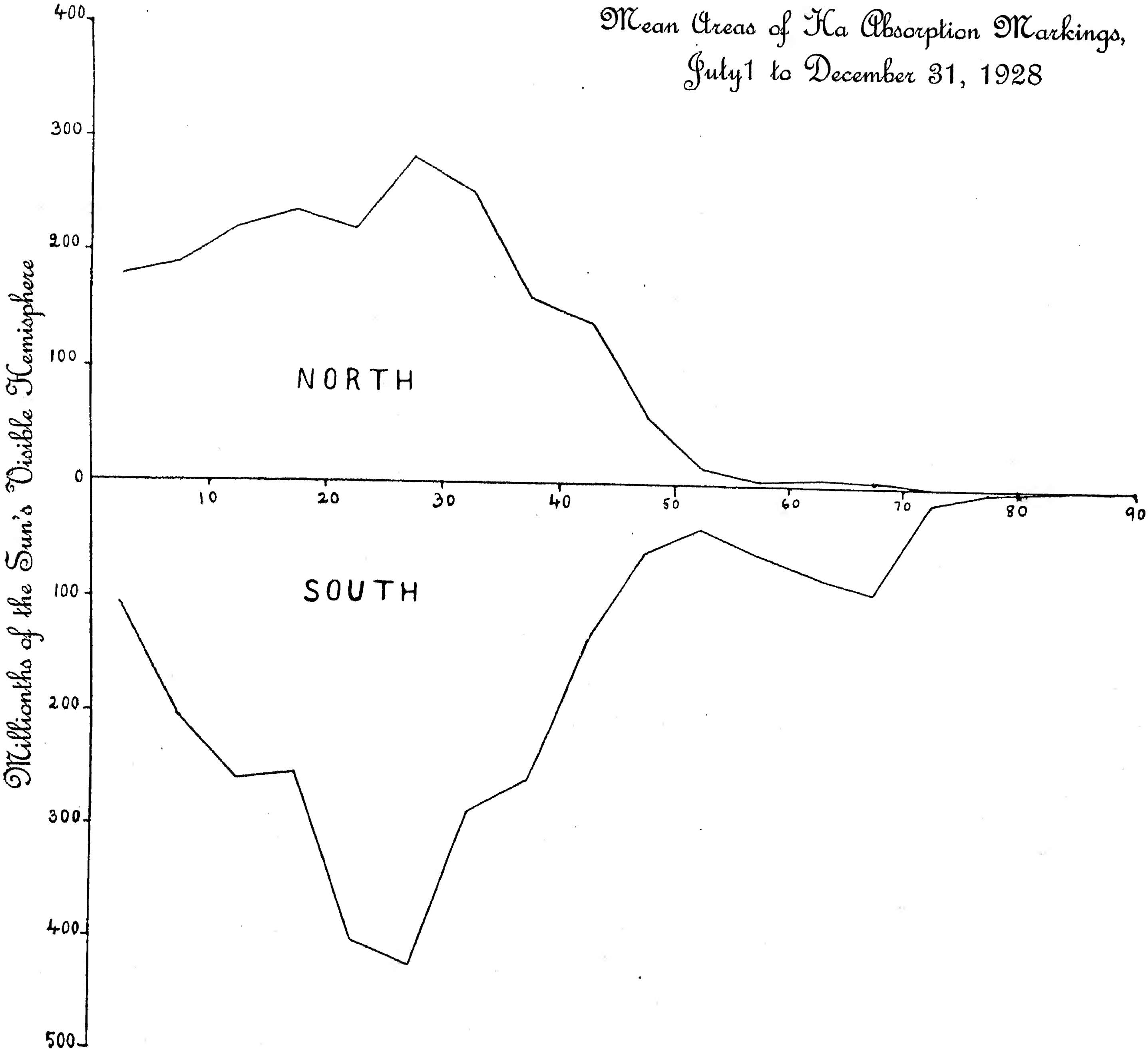
	Mean daily areas.	Mean daily numbers.
North	1,999	14·1
South	2,783	16·6
Total ...	4,782	30·7

The above show an increase of about 28 per cent in areas and an increase of 4 per cent in numbers compared with the previous half-year. The preponderance of activity in the southern hemisphere still continues in contrast to the northern preponderance of prominences at the limb.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 140 days of observation being reckoned as 126¾ effective days.

	Mean daily areas.	Mean daily numbers.
North (Kodaikanal photographs only)	1,900	12·18
South (do.)	2,701	14·90
Total ...	4,601	26·08

The distribution of the mean daily areas in latitude is shown in the following diagram. The maximum activity which persisted within the zone 10° to 20° in the previous half-year has now considerably shifted towards the poles, the zones of maximum activity now being 25° to 35° in the northern and 20° to 30° in the southern hemisphere as is seen from the diagram.



The excess of activity with regard to areas and numbers still persists in the western hemisphere, the percentage east being 49·00 for areas and 49·86 for numbers.

Thanks are due to the co-operating observatories for the photographs supplied by them.

THE OBSERVATORY, KODAIKANAL,
8th August 1929.

A. L. NARAYAN,
Assistant Director.

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Kodaikanal Observatory.

BULLETIN No. LXXXVII.

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE FIRST HALF OF THE YEAR 1929.

In pursuance of the programme of work adopted since 1st January 1923 under the auspices of the International Astronomical Union, all observatories taking spectroheliograms of the sun have been asked to co-operate with the Kodaikanal Observatory by supplying copies of their photographs on those days when the Kodaikanal records are imperfect or wanting. In response to our requirements for the first half of the year 1929, the Mount Wilson Observatory supplied prominence plates for 10 days and Hα disc plates for 11 days; Meudon Observatory supplied K_3 disc plates for 20 days and Hα disc plates for 17 days; the Pitch Hill Observatory (Mr. Evershed's) at Ewhurst, Surrey, England, supplied six prominence plates and eight Hα disc plates; and the Yerkes Observatory supplied two prominence plates and six Hα disc plates.

When only incomplete or imperfect photographs for any day are available from more than one observatory, the best photograph is chosen as representing the solar activity of that day after weighting it according to its quality, and the remaining photographs are ignored.

The mean daily areas and numbers of prominences during the half-year are given below. The means are corrected for incomplete or imperfect observations, the total of 177 days for which plates were available being reduced to 160¾ effective days.

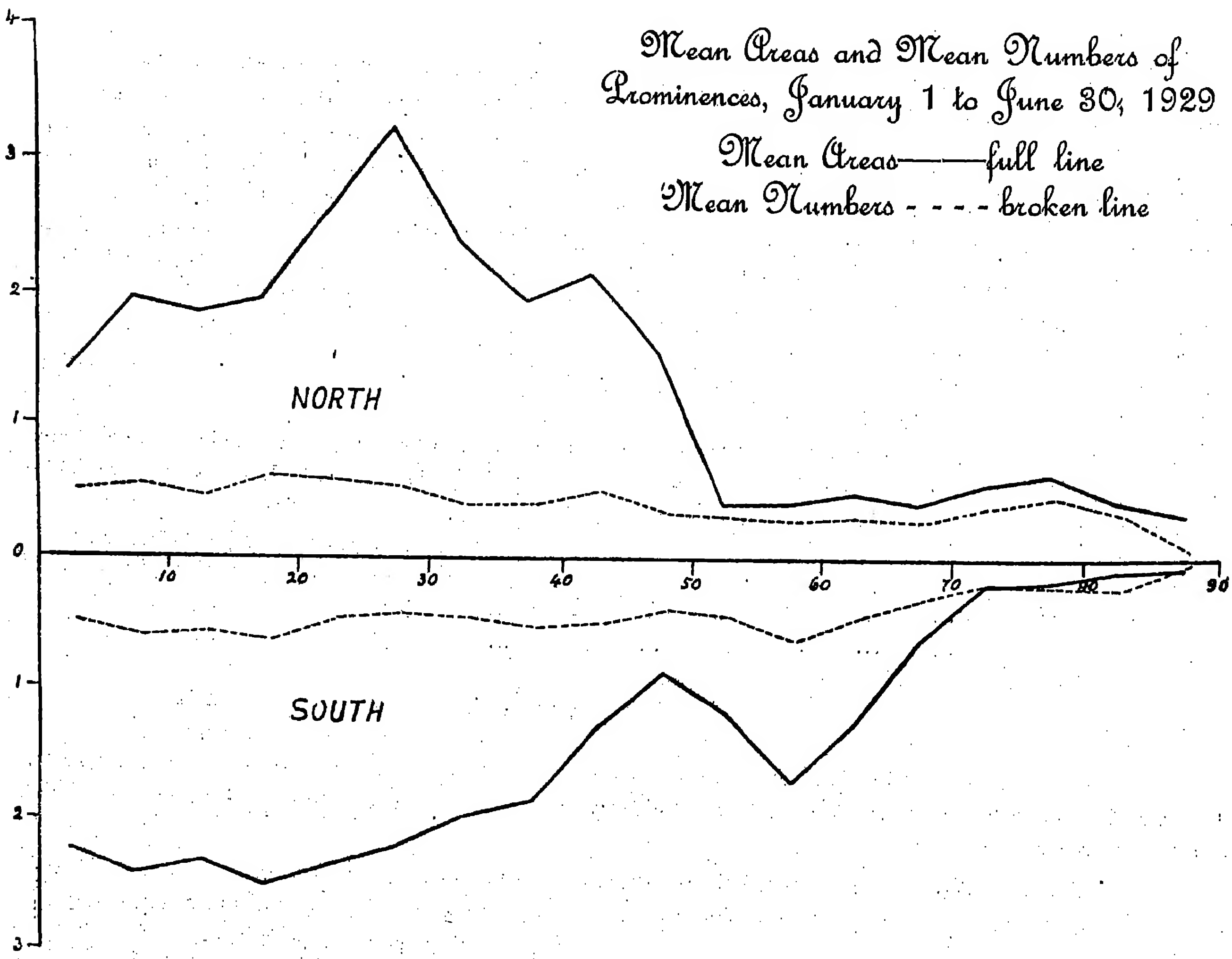
	Mean daily areas (square minutes).	Mean daily numbers.
North	2·46	7·13
South	2·52	7·48
Total ...	4·98	14·61

Compared with the previous half-year areas show a decrease of about 27·2 per cent and numbers a decrease of about 15·3 per cent. The southern hemisphere has now begun to exhibit a slight predominance of activity over the northern.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 162 days of observation being counted as 149 effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North (Kodaikanal photographs only)	2·55	7·49
South (do.)	2·58	7·74
Total ...	5·13	15·23

The distribution of prominences in latitude is represented in the following diagram, in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude. The ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line. Compared with the previous half-year the diagram shows some slight changes in the distribution of activity in the various zones. In the northern hemisphere the high peak of activity in the region 25°—35°, is now confined to the zone 25°—30°, the minor peak near 50° has moved 5° towards the equator and the activity in high latitudes has practically disappeared. In the southern hemisphere the distribution is more uniform in low latitudes and the activity in high latitudes has become less marked and shifted 5° downwards.



The monthly, quarterly and half-yearly areas and numbers, and the mean height and mean extent of the prominences on photographs from all co-operating observatories are given in Table I. The unit of area is 1 square minute of arc. The mean height is derived by adding together the greatest heights reached by individual prominences and dividing by the total number of prominences observed; the mean extent is derived by adding together the lengths of the base on the chromosphere of individual prominences and dividing by the total number of prominences.

TABLE I.—ABSTRACT FOR THE FIRST HALF OF 1929.

Months.	Number of days (effective).	Areas.	Numbers.	Daily Means.		Mean height.	Mean extent.
				Areas.	Numbers.		
1929.						"	°
January	30¼	215·2	538	7·1	17·8	35·1	5·7
February	24½	152·8	431	6·2	17·6	33·1	6·1
March	31	197·7	405	6·4	13·1	40·5	7·0
April	26½	97·2	411	3·7	15 5	34·7	4·6
May	27¼	78·8	329	2·9	12·1	36·1	5·7
June	21¼	57·5	254	2·7	12·0	38·1	4·9
First quarter	85¾	565·7	1,374	6·6	16·0	36·1	6·2
Second quarter	75	233·5	994	3·1	13·3	36·0	5·0
First half-year	160¾	799·2	2,368	5·0	14·8	36·0	5·7

Distribution east and west of the Sun's axis.

As in the previous half-year, both areas and numbers showed an excess at the west limb compared with the east limb as will be seen from the following table :—

1929 January to June.	East.	West.	Percentage East.
Total number observed	1,164	1,204	49·2
Total areas in square minutes	387·4	411·9	48·5

Metallic prominences.

Forty-seven metallic prominences were observed during the half-year. Their details are given below :—

TABLE II.—LIST OF METALLIC PROMINENCES OBSERVED AT KODAIKANAL, JANUARY TO JUNE 1929.

Date.	Hour I.S.T.	Base.	Latitude.		Limb.	Height.	Lines.
			North.	South.			
1929.	H. M.	°	°	°		"	
January 4	8 50	2	8		W	10	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1.
6	9 18	5	9·5		W	20	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5316·8, D_2, D_1.
12	10 33	1		30·5	W	10	5018·6, b_4, b_3, b_2, b_1, D_2, D_1.
13	9 12	2		32	W	20	5018·6, b_4, b_3, b_2, b_1, 5316·8, D_2, D_1, 6677.

Date.		Hour I.S.T.		Base.	Latitude.		Limb.	Height.	Lines.
					North.	South.			
1929.		H.	M.	°	°	°		″	
January	15	9	10	4	19		W	25	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5270·0, 5276·2, 5316·8, 5363·0, D_2, D_1.
	18	10	25		6		E		b_4, b_3, b_2, b_1, 5316·8, D_2., D_1, 6677, 7065.
	20	9	45	10	10		E	20	4924·1, 5016, 5018·6, 5048, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
February	11	9	9	1		13·5	E	10	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	13	9	45	5	7·5		W	10	4922·0, 4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5197·6, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	16	10	16	2		7	W	10	5016. 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	18	9	11	3		10·5	W	10	5018·6, b_4, b_3, b_2, b_1, 5276·2, 5316·8, D_2, D_1, 6677.
	20	9	30	1		8·5	E	10	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 7065.
	20	10	9			5	W	5	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	24	9	10	4		32	E	20	5018·6, b_4 b_3, b_2, b_1, 5276·2, 5316·8, 5363·0, D_2, D_1.
	24	9	5	3		13·5	W	15	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5270, 5276·2, 5316·8, 5363·0, D_2, D_1, 7065.
	25	8	59	3	32·5		E	30	5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, D_2, D_1.
	25	9	13	3		16·5	W	25	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5270·0, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
March	2	9	7	1		8·5	E	10	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0.
	2	9	50	3	7·5		W		b_4, b_3, b_2, b_1, D_2, D_1.
	4	9	7	4		9	E	25	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	5	9	18	2	27		E	20	5018·6, b_4, b_3, b_2, b_1, 5276·2, 5316·8, D_2, D_1.
	6	10	58	3	13·5		W	10	5018·6, b_4, b_3, b_2, b_1, 5276·2, 5316·8, D_2, D_1.
	8	9	54		26		E	15	b_4, b_3, b_2, b_1, D_2, D_1.
	8	9	10	1	12·5		W	10	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5233·0, 5276·2, 5316·8, D_2, D_1. 6677, 7065.
	17	9	12	3	24·5		E	20	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5276·2, 5316·8, D_2, D_1.
	18	8	58	3	28·5		E	15	5018·6, b_4, b_3, b_2, b_1, 5276·2, 5316·8, D_2, D_1.
	18	8	51	3		3·5	E	20	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5276·2, 5316·8, 5363·0, D_2, D_1.
	18	9	15	5		10·5	W	15	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5270·0, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	19	9	4	3		15·5	E	25	b_4. b_3, b_2, b_1, 5316·8, D_2, D_1.
	22	9	50	7		9·5	E	20	4924·1, 5018·6, 5142·0, b_4, b_3, b_2, b_1, 5198, 5270, 5363·0, D_2, D_1, 6677, 7065.
	30	9	17	5		11·5	E	25	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, D_2, D_1, 6677.
April	1	8	58	3		11·5	W	20	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5276·2, 5316·8, D_2, D_1.
	3	8	51	5		12·5	E	20	5018·6, b_4, b_3, b_2, b_1, 5316·8. D_2, D_1.
	4	10	55	1	11·5		W	15	4924·1, 5018·6, b_4, b_3, b_2. b_1, D_2, D_1, 6677.
	12	9	5	3	13·5		W	15	4924·1, 5018·6, b_4, b_3, b_2. b_1, 5316·8, D_2. D_1, 6677.
	13	9	25	1		11·5	E	10	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5233, D_2, D_1, 6677.
	16	10	20	2	15		E	20	5018·6, b_4, b_3, b_2, b_1. 5234·8, 5276·2, 5316·8. D_2, D_1.
	19	9	0	4	5		E	20	5018·6, b_4. b_3, b_2, b_1, 5234·8 5276·2, 5316·8, 5363·0, D_2, D_1, 6677.
	20	8	5	4	20		E	30	5018·6, b_4, b_3, b_2, b_1, 5234·8, 5316·8. D_2, D_1.
	24	10	9	4	5		W	15	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	28	9	8			20	E		b_4, b_3, b_2, b_1, D_2, D_1 (thick sky).
	29	8	50	4	6		W		4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, D_2, D_1.
May	5	8	40	2	11		E	15	4924·1, 5018·6, b_4, b_3, b_2 b_1, 5276·2, 5316·8, D_2, D_1.
	8	8	50	4	19		W	20	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1.
	16	9	5	1		7·5	W	15	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5316·8, 5363, D_2, D_1, 6677, 7065.
	16	9	10	1		11·5	W	10	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5316·8, D_2, D_1, 6677, 7065.
June	27	10	7	1		14·5	W		4924·1, 5018·6, b_4, b_3, b_2, b_1, D_2, D_1, 6677.

The distribution of metallic prominences was as follows :—

	1°—10°	11°—20°	21°—30°	31°—40°	Mean latitude.	Extreme latitudes.
North	9	9	4	1	12·6	5° and 32°·5
South	10	11	1	2	13·6	3°·5 and 32°

Twenty-three were on the east limb and 24 on the west limb.

Displacements of the hydrogen lines.

Particulars of the displacements observed in the chromosphere and prominences are given in the following table :—

TABLE III.—DISPLACEMENTS OF THE HYDROGEN LINES, JANUARY TO JUNE 1929.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1929.		H.	M.	°	°		A.	A.	A.	
January	1	9	5	64		W	0·5			At top.
	2	9	20	21		E	1			In chromosphere.
	3	9	11		6	W		0·5		At base.
	3	9	8	38		W	1			At top.
	3	9	6	64		W		0·5		At base.
	4	8	58		20	E	0·5			Do.
	4	8	50	9		W	1			At top.
	5	9	47		26	W	1·5	1		To red at top ; to violet at base.
	5	9	44	11·5		W	1			At top.
	5	9	42	17·5		W	1			Do.
	6	8	53	42		E		0·5		At base ; extends over 6° from 39° to 45°.
	6	9	18	11		W	2·5			At top.
	6	9	18	8		W		1·5		At base.
	7	11	13		18	E	0·5			Do.
	7	11	6	6		W	1			At top.
	9	11	33	45		E	1			Do.
	10	13	41	50		E	1·5			Do.
	10	13	44	35		E			Slight	
	10	13	37		58	W	1			At base.
	11	11	0	7		W		1		At base ; extends over 2° from 6° to 8°.
	11	10	55	44		W		Slight		At base.
	11	10	1	56·5		E			2	At base ; extends over 9° from 52° to 61°
	11	9	55	22		E	1			At base.
	11	9	31		78	E	1			At top.
	14	9	2	36		W		0·5		Do.
	15	9	22	10		E	0·5			Do.
	16	9	56	10		E			1	At base.
	16	10	23		10	E		1		At top.
	16	10	34		18	E	1			Do.
	16	9	46		27	W	1			Do.
	16	9	27	16		W	Slight			Do.
	16	9	24	54		W	Do.			Do.
	17	10	10	29		E	1·5			At top.
	17	9	49		41	W	1			Do.
	17	9	49		37	W	0·5			Do.
	17	9	39		12	W	1			Do.
	17	9	35	9·5		W	1			Do.
	17	9	10	42		W			Slight	At base.
	18	10	20	15		E			1	Do.
	18	10	18	6		E	1·5	2		Do.
	18	9	20	45		W			Slight	
	19	9	48	12		E		1		At top.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1929.		H.	M.	°	°		A.	A.	A.	
January	19	10	8	10		E	1			At top.
	19	9	47	4		E	1			Do.
	19	9	43		27	E		1		Do.
	19	9	30		84	W	2	1		In chromosphere.
	20	9	45	14		E	0·5			At base.
	20	9	45	11		E		1		At top.
	21	9	29		18	W		0·5		At base.
	21	9	21	10		E	1			Do.
	21	9	26	20		W	Slight			At top.
	22	9	25	57·5		E	Do.			At base.
	22	9	52		19	E	0·5			Do.
	22	9	34		22	W	1	0·5		To red at top ; to violet at base.
	23	10	3	42		E	Slight			At base.
	23	10	3	41		E	0·5			At top.
	23	9	45	15		E		2		Do.
	26	10	7	15·5		E	1			Do.
	26	10	5	42		E		Slight		Do.
	26	10	16		49	W		1		Do.
	27	9	18	29		E		Slight		Do.
	27	9	20	20		E	1			In chromosphere.
	27	9	2		11	W		0·5		Do.
	28	12	11	18		E		0·5		At top.
	28	12	4		9	W		0·5		At base.
	29	11	0		13	W	1·5	1		To violet at base.
	29	10	50	21		W		Slight		At base.
	31	10	45	46·5		E	1			At top ; extends over 7° from 43° to 50°.
	31	10	47	32		E	1			At top.
	31	10	48	25·5		E		1		At base.
	31	10	18	8		W			Slight	Do.
February	1	9	35	12		E		Slight		At top.
	1	9	16	13·5		W		1		Do.
	6	11	52	17·5		E		1		At top ; extends over 3° from 16° to 19°.
	6	11	52	18		E		2		At top.
	6	11	0		85	E	Slight			
	9	10	5		4	E		13		At top.
	9	10	10		10	E	1			Do.
	9	11	17	3		W	1	2		To red at top ; to violet at base.
	10	9	47		11	E		Slight		At top.
	10	9	46		14	E		1		Do.
	11	8	47		11	E		1		Do.
	11	8	47		16	E	2			Do.
	12	9	29	24·5		E	0·5			Do.
	12	9	41		35·5	E	0·5			At base ; extends over 3° from 34° to 37°.
	12	9	43		58	E	Slight			At base.
	12	8	50	41·5		W	Do.			Do.
	13	9	25	60		E		1		
	13	10	7	7		W	2			At base.
	14	9	35	14·5		E	1·5			At top.
	14	9	40		23	E	Slight			At base.
	14	9	45		43	E	Do.			Do.
	14	9	15	4		W	1·5			Do.
	14	9	14	12·5		W	1			At top.
	14	9	12	19		W	Slight			At base.
	14	9	10	34		W			Slight	Do.
	15	8	50	75		E	Slight			At top.
	15	9	45	6		E		0·5		At base.
	15	9	54		30	E		1·5		No prominence.
	15	9	15	10		W	1			At top.
	16	10	5	27		E	2			No prominence.
	16	9	50	13·5		E	4			At top ; extends over 7° from 10° to 17°.
	16	9	51	15		E		2		At top.
	16	9	51	11		E	5	2		Both at top.
	16	9	40		86	E		1		At top.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1929.		H.	M.	°	°		A.	A.	A.	
February	16	10	14		44	W		0·5		No prominence
	16	10	16		14	W		2		At top.
	16	10	16		7	W		2		The whole prominence from 6° to 8° was displaced ; displacement seen in D_2, D_1, D_3 and b_4, b_3, b_2, b_1.
	17	9	46	15		E	1			
	18	9	13	25		E	1			At top.
	18	9	8	10		W	Slight			Do.
	19	8	50	48		E	0·5	1·5		To violet at top ; to red at base.
	19	9	13		44	E	0·5			At base.
	19	9	2		54	W		1		At top.
	19	8	55		12	W		0·5		At base.
	20	9	25		5	E	1			At top.
	20	9	25		3·5	E		0·5		Do.
	20	9	25		16	E	0·5			No prominence.
	20	10	9		5	W	1			At top.
	21	9	53	4		E		1·5		At base.
	21	9	10	6		W	3	1		Both at base.
	22	9	36	11·5		E	1			At base.
	22	9	17		1·5	W			1	Do.
	22	9	15	5		W	Slight	1		To violet at base.
	22	9	7	50·5		W	Do.			At top.
	23	9	57	36·5		E		2		At base.
	23	9	39		6·5	E		1		Do.
	23	9	39		8·5	E	1			At top.
	24	8	55	49·5		E		Slight		
	24	8	53	17		E		1		At top.
	24	9	5		14	W		1·5		Do.
	25	8	59	32		E		0·5		At base.
	25	8	48	19		E	0·5			At top.
	26	9	2	38		E		0·5		At base.
	26	9	2	23·5		E	1·5			At top.
	27	9	24	12		E		2		Do.
	28	9	35		10	E	0·5			At base.
	28	9	13	10·5		W			0·5	
March	1	9	25	58		E	2			At top ; extends over 4° from 56° to 60°.
	1	9	7	8		W	0·5			At base.
	2	9	7		8·5	E	3	2		
	3	9	53	46·5		W	1			At top.
	4	8	51	59·5		E	0·5			Do.
	4	9	7		9	E	1	2·5		To red at base ; to violet at top.
	4	9	12		13	E		0·5		At top.
	4	9	2		4	W		Slight		At base.
	5	9	23	69		E	Slight			At top.
	5	9	7		7	E	0·5			At base.
	5	9	28	39		W	1·5			At top.
	5	9	28	38·5		W		1		At base.
	5	9	25	82·5		W		Slight		No prominence.
	6	10	14	14		E	1			At top.
	6	11	3		23	W	1			Do.
	6	10	45	8		W	1·5	1		To red at top ; to violet at base.
	6	10	58	13		W	0·5			At top.
	7	9	18	25·5		E		0·5		No prominence.
	7	9	25	12		E	1·5			At top.
	7	9	32		11	E	2			Do.
	7	8	55	18		W	0·5			Do.
	8	9	54	26		E	0·5			Do.
	8	10	16		55·5	E		1		Do.
	8	9	4	12·5		W	2			At base.
	8	8	54	26·5		W	1·5			Do.
	10	8	48	78		E		Slight		
	10	9	0		53·5	W	Slight			At top.
	12	9	38	10		E	0·5			At base.
	12	8	44	33·5		W	Slight			At top.
	13	8	59	65		E		Slight		

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1929.		H.	M.	°	°		A	A.	A.	
March	13	9	1	77		W	0·5			At top.
	14	8	58		57·5	W		1		At base.
	15	9	37	10·5		E	2·5	0·5		To red at top ; to violet at base.
	15	8	55	42·5		W	Slight			At top.
	16	9	38	39 5		E			Slight	Do.
	16	9	49		11·5	E	1·5			
	16	9	16		3	W		0·5		At base.
	16	9	15	1·5		W	Slight			Do.
	17	9	7		10	W		1		Do.
	18	8	58	28		E	Slight			At top.
	18	8	55	20		E		1·5		Do.
	18	9	15		11	W	2·5	1·5		To red at top; to violet at base.
	18	9	15		7	W	1			At top.
	19	8	48	52·5		E		0·5		At base.
	19	9	4		11	E		1·5		At top.
	20	10	0	19·5		E		1		Do.
	20	10	8		25·5	E			Slight	
	21	10	5	52		E	2·5			At top.
	21	9	35		23	W	1·5			Do.
	21	9	12	33		W	Slight			Do.
	22	9	38	14·5		E	0·5			Do.
	22	9	50		9·5	E	1			Do.
	23	9	30		3	E	1·5			At base.
	23	9	43		78·5	E			2	At top.
	23	9	13	18		W		0·5		At base.
	24	8	50	35·5		E	Slight			At top.
	24	9	00		19	W		0·5		
	24	8	57		4	W		Slight		
	25	8	46	46·5		E	1			At base.
	25	8	49	43		E	1·5			At top.
	25	9	00		33·5	E	0·5			At base.
	26	9	00	35·5		E		1		Do.
	26	9	15		72·5	W	0·5			Do.
	27	8	58	9		W		0·5		No prominence.
	28	9	5	16·5		E		1·5		At base.
	28	8	51		3·5	W	0·5			At top.
	29	9	2	21·5		E	1			Do.
	29	9	9	2·5		E	0·5			Do.
	29	9	13		20	E	0·5			Do.
	29	8	47	3		W	1			At top.
	30	9	2	44·5		E	1	1		At base.
	30	9	14	28		E	Slight			Do.
	30	9	17		17	E		1·5		At top.
	30	9	18		24	E		1		Do.
	31	9	1	7		E		1		At base.
April	1	9	4	29		E		1		At top.
	1	8	58		10	W		1·5		Do.
	2	8	50	46		E		0·5		At base.
	2	9	1	28		E		1		At top.
	2	8	55		83	E	1			Do.
	3	9	00	9		E	Slight			At base.
	4	10	55	11·5		W	0·5			Do.
	5	9	30		28	E		1·5		Do.
	5	9	12	28		W	0·5			At top.
	6	9	43		19	E	1			Do.
	6	9	30	20		W	Slight			Do.
	7	9	00	18		W	1	1·5		To red at top ; to violet at base.
	8	8	56	30		E	0·5			At top.
	8	8	50	11		E	0·5			At base.
	8	8	50	10		E		1·5		At top.
	8	8	58	8		E	2			Do.
	8	8	48	82		W		Slight		At base.
	12	8	47	83		E	Slight			At top.
	12	9	26	16		E	2			Do.
	12	9	5		16	W	1			Do.
	12	8	56	66·5		W	0·5			Do.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North	South		Red.	Violet.	Both ways.	
1929.		H.	M.	°	°		A.	A.	A.	
April	13	9	10	59·5		E		1		At top.
	13	9	12	49 5		E			1	
	13	9	25		11·5	E	2·5			
	13	9	00		9·5	W		Slight		At base.
	13	8	52	26·5		W	Slight			At top.
	13	8	41	77·5		W		Slight		At base.
	14	9	34		12	W	1			At top.
	15	8	57	46·5		E		1		At base.
	15	9	3		7	W	1			At top.
	16	10	2	23		E	1			Do.
	16	10	20	15		E		0·5		At base.
	18	9	41	83·5		W	Slight			Do.
	19	9	00	6		E	1			At top.
	20	8	5	15		E		1		At base.
	20	9	7		13	E	0·5			Do.
	21	8	51	21		E	1·5			Do.
	22	11	30	3		W	1			At top.
	24	10	9	2		W		0·5		At base.
	24	10	9	6		W	1 5	0·5		To red at top ; to violet at base.
	25	9	8	3		W	2			At top.
	25	9	8	5		W		1·5		At base.
	26	9	7	18·5		W	Slight			At top.
	27	10	10	16		E	1			Do.
	27	10	18		11	E		2		Do.
	28	9	8		20	E	1·5			At base.
	28	9	10		28	E	1	1·5		To red at base ; to violet at top.
	29	9	0	6		E	1			
	29	8	52		13	E	0·5			At base.
	29	8	50	7		W	1	0·5		To red at top ; to violet at base.
	30	8	50		11	E	1·5	1		To red at base ; to violet at top.
	30	8	46		78·5	W		0·5		At base.
	30	8	43		9	W		1		Do.
	30	8	41	16		W	1			At top.
May	1	8	36	49		W		Slight		At base.
	5	8	33	35		E	1			At top
	5	8	40	15		E	1·5			At base.
	5	8	40	12		E		1·5		At top.
	5	8	40	6		E	1			At base.
	6	9	10	9		E	0·5			At top.
	7	8	34	8		W		0·5		At base.
	8	8	56	7		E	0·5			Do.
	8	8	45		26	W	6	0·5		To red at top; to violet at base.
	10	9	37		14·5	W	1			At top.
	10	9	27	18		W	Slight			At base.
	13	9	15	1		E	0·5			Do.
	13	9	15		4	E		1		At top.
	14	8	53	33		E		Slight		At base.
	14	8	58	23		E	1			Do.
	14	8	59		1	E	0·5			Do.
	15	8	42	45		E		1		Do.
	15	9	2		25	W	1	0·5		To red at top ; to violet at base.
	15	9	0		16	W	1			At top.
	16	9	4		7·5	W	1			
	16	8	41	24·5		W			Slight	At top.
	17	9	24	87·5		W		Slight		
	18	8	54		4	W	Slight			At top.
	18	8	47	51·5		W	1	0·5		To red at base ; to violet at top.
	19	9	16	25		E	0·5			At top.
	20	9	22	46		E	0·5			At base.
	21	8	44	36		E	1			Do.
	21	8	34	9		W	Slight			Do.
	22	8	46	14		E	1			Do.
	24	9	18	70		W	Slight			Do.
	25	10	22	11		W			1	Do.
	25	10	21	19		W	1	0·5		To red at top ; to violet at base.
	25	10	17	59		W	0·5			At top.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1929.		H.	M.	°	°		A.	A.	A.	
May	26	9	3		8	W		1		At base.
	26	9	1	1		W	2			At top.
	31	9	3		15·5	W			0·5	
	31	8	58	11		W	0·5			At top.
June	9	9	33	25		E	1			At top.
	10	9	37	13		E	Slight			At base.
	10	9	40		18	E	0·5			Do.
	13	9	30	2		E	1			At top.
	13	9	28		37	E	1	0·5		To red at top ; to violet at base.
	13	8	58	28		W		1		
	17	9	20	21		E	0·5			
	17	9	22		8	E	1·5			At top.
	17	9	16		16	W		1		At base.
	18	8	51	19		E		1		At top.
	18	8	51	13		E	0·5			At base.
	18	8	54		2	E		1		At top.
	18	8	54		5	E	1			At base.
	18	8	48	16		W		0·5		Do.
	18	8	45	25		W	0·5			At top.
	23	8	52		20	E	0·5			At base.
	24	8	50	26·5		E		0·5		At top.
	27	10	17		14·5	W			1	At base.
	27	10	14		0·5	W	0·5			Do.

The total number of displacements was 348 as against 281 in the previous half-year and their distribution was as follows :—

Latitude.	North.	South.
1°—30°	150	100
31°—60°	58	16
61°—90°	15	9
Total ...	223	125
East limb		194
West limb		154
Total ...		348

Reversals and displacements on the Sun's disc.

Four hundred and forty-eight bright reversals of the Hα line, 436 dark reversals of D_3 line and 98 displacements of the Hα line were observed during the half-year. Their distribution is given below :—

	North.	South.	East.	West.
Bright reversals of Hα	238	210	218	230
Dark reversals of D_3	236	200	215	221
Displacements of Hα	50	48	46	52

Seventy-two displacements were towards the red, 25 towards the violet and 1 both ways simultaneously.

Prominences projected on the disc as absorption markings.

Photographs of the Sun's disc in Hα light were available from Kodaikanal and the co-operating observatories for a total of 176 days, which were counted as 171½ effective days. The mean daily areas of Hα

absorption markings (corrected for foreshortening) in millionths of the Sun's visible hemisphere and their mean daily numbers are given below :—

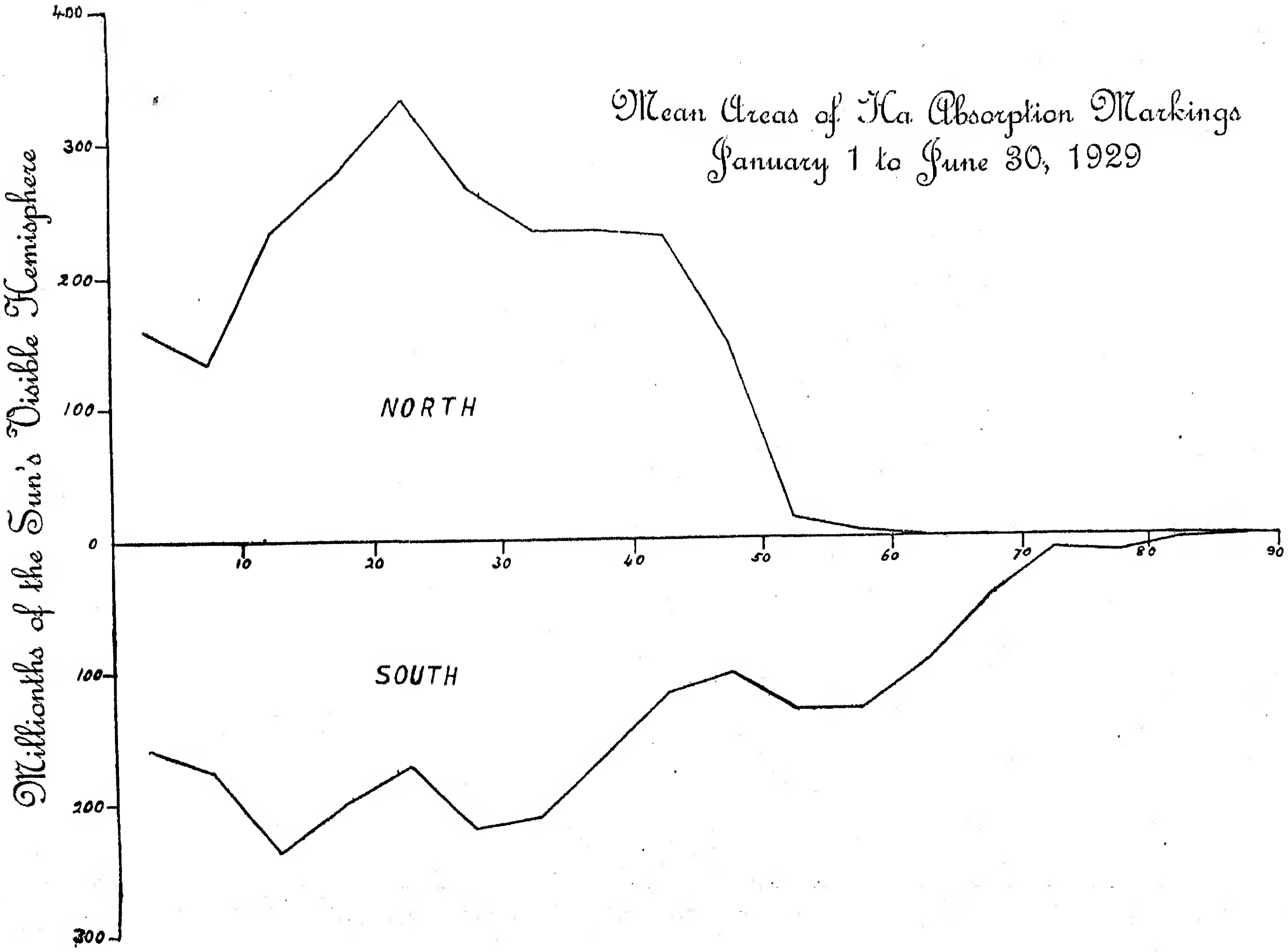
	Mean daily areas.	Mean daily numbers.
North	2,277	12·5
South	2,192	12·8
Total ...	4,469	25·3

The above show a decrease of about 6·5 per cent in areas and of 17·6 per cent in numbers compared with the previous half-year. The preponderance of activity is now in the northern hemisphere.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 156 days of observation being reckoned as 150 effective days.

	Mean daily areas.	Mean daily numbers.
North (Kodaikanal photographs only)	2,359	12·95
South (do.)	2,101	12·60
Total ...	4,460	25·55

The distribution of the mean daily areas in latitude is shown in the following diagram. The maximum of activity which existed near 30° in the northern hemisphere has shifted 5° towards the equator, and the high peak in the southern hemisphere has disappeared, leaving the distribution more uniform than in the previous half-year.



The excess of activity with regard to areas and numbers still persists in the western hemisphere, the percentage east being 48·61 for areas and 49·71 for numbers.

Thanks are due to the co-operating observatories for the photographs supplied by them.

THE OBSERVATORY, KODAIKANAL,
19th April 1930.

A. L. NARAYAN,
Officiating Director, Kodaikanal and Madras Observatories.

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Kodaikanal Observatory.

BULLETIN No. LXXXVIII.

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE SECOND HALF OF THE YEAR 1929.

In pursuance of the programme of work adopted since 1st January 1923 under the auspices of the International Astronomical Union, all observatories taking spectroheliograms of the sun have been asked to co-operate with the Kodaikanal Observatory by supplying copies of their photographs on those days when the Kodaikanal records are imperfect or wanting. In response to our requirements for the second half of the year 1929, the Mount Wilson Observatory supplied prominence plates for 59 days and Hα disc plates for 33 days; Meudon Observatory supplied K_3 disc plates for 3 days and Hα disc plates for 36 days; the Pitch Hill Observatory (Mr. Evershed's) at Ewhurst, Surrey, England, supplied 7 prominence plates and 5 Hα disc plates.

When only incomplete or imperfect photographs for any day are available from more than one observatory, the best photograph is chosen as representing the solar activity of that day after weighting it according to its quality, and the remaining photographs are ignored.

The mean daily areas and numbers of prominences photographed during the half-year by means of the K line of calcium are given below. The means are corrected for incomplete or imperfect observations, the total of 183 days for which plates were available being reduced to 165 effective days.

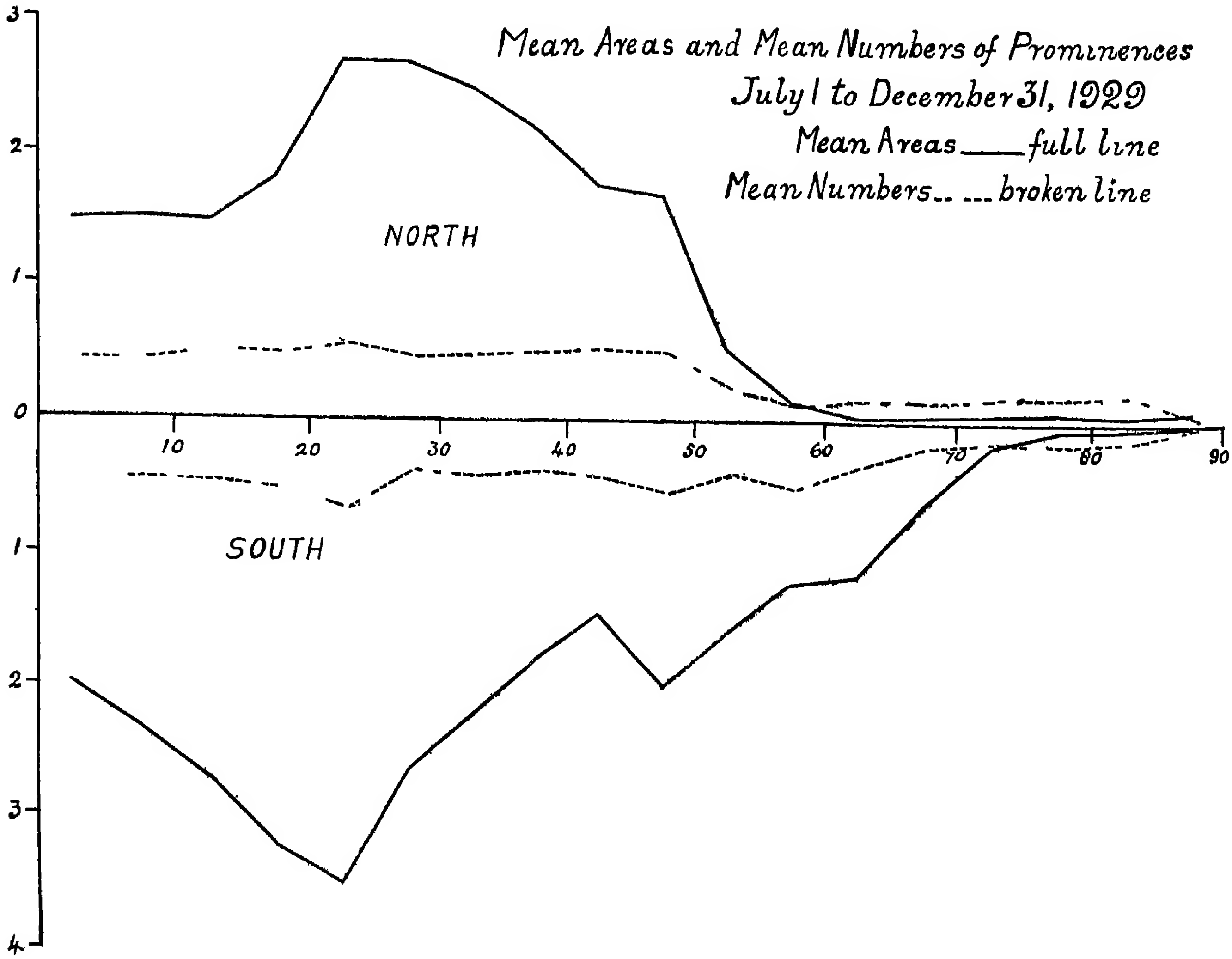
	Mean daily areas (square minutes).	Mean daily numbers.
North	2·09	6·26
South	2·86	6·62
Total ...	4·95	12·88

Compared with the previous half-year, areas have decreased in the northern hemisphere but increased in the southern, giving no appreciable change in the total; numbers continue to decrease, the percentage decrease on the previous half-year being 11·8.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 149 days of observation being counted as 129 effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North (Kodaikanal photographs only)	2·04	6·84
South (do.)	3·02	7·23
Total ...	5·06	14·07

The distribution of prominences in latitude is represented in the following diagram, in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude. The ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line. The distribution of prominence areas is generally similar to that in the previous half year. The activity between 55° N and 90° N has now almost disappeared, whilst in the southern hemisphere there is greater activity from 10° S to 30° S and near 50° S.



The monthly, quarterly and half yearly areas and numbers, and the mean height and mean extent of the prominences on photographs from all co-operating observatories are given in Table I. The unit of area is 1 square minute of arc. The mean height is derived by adding together the greatest heights reached by individual prominences and dividing by the total number of prominences observed; the mean extent is derived by adding together the lengths of the base on the chromosphere of individual prominences and dividing by the total number of prominences.

TABLE I.—ABSTRACT FOR THE SECOND HALF OF 1929.

Months.	Number of days (effective).	Areas.	Numbers.	Daily means.		Mean height.	Mean extent.
				Areas.	Numbers.		
1929.						″	°
July	$24\frac{3}{4}$	88·9	325	3·6	13·1	39·0	5·5
August	$29\frac{1}{4}$	111·3	342	3·8	11·2	42·0	6·2
September	$28\frac{3}{4}$	172·3	411	6·0	14·3	35·4	7·2
October	$27\frac{3}{4}$	145·5	362	5·3	13·0	29·9	7·0
November	$26\frac{1}{4}$	147·1	336	5·6	12·8	38·6	7·0
December	$28\frac{1}{4}$	152·3	350	5·4	12·4	42·5	7·4
Third quarter	$82\frac{3}{4}$	372·5	1,078	4·5	13·0	38·6	6·4
Fourth quarter	$82\frac{1}{4}$	444·9	1,048	5·4	12·7	36·9	7·3
Second half-year	165	817·4	2,126	5·0	12·9	37·8	6·9

Distribution east and west of the Sun's axis.

Unlike the previous half-year, the areas are almost equally divided between the east and west of the sun's axis, whereas the numbers show an excess at the east limb as will be seen from the following table :—

1929 July to December.	East.	West.	Percentage East.
Total number observed	1,103	1,022	51·9
Total areas in square minutes	408·3	408·2	50·0

Eruptive prominence.

A large eruptive prominence was observed on the 5th September 1929. A prominence extending from latitudes 20° to 45° in the south-west quadrant developed into a large arch, the brightest portion of which could be traced for over $2\frac{1}{2}$ hours, ultimately reaching a height of 13′ above the sun's surface before fading away. At the same time an arched prominence extending from latitudes 55° to 82° in the south-east quadrant remained almost unchanged in appearance.

Metallic prominences.

Twenty-five metallic prominences were observed during the half-year. Their details are given below :—

TABLE II.—LIST OF METALLIC PROMINENCES OBSERVED AT KODAIKANAL, JULY TO DECEMBER 1929.

Date.	Hour I.S.T.	Base.	Latitude.		Limb.	Height.	Lines.
			North.	South.			
1929.	H. M.	°	°	°		″	
July 4	9 23		11		E	15	4924·1, 5016, b_4, b_3, b_2, b_1, 5316·8, 5363·0, D_2, D_1, 6677.
17	12 25			6	W	5	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5316·8, 5363·0, D_2, D_1.
20	11 21	2	7		E	10	4924·1, 5018·6, b_4, b_3, b_2, b_1, D_2, D_1, 6677.

Date.		Hour I.S.T.	Base.	Latitude. North.	Latitude. South.	Limb.	Height.	Lines.
1929.		H. M.	°	°	°		″	
August	14	8 50	5		6·5	W	10	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363, D_2, D_1, 6677.
	27	9 20		9		W	10	Faint b_4, b_3, b_2, b_1, D_2, D_1.
September	13	9 16		8		E	10	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5269·8, 5316·8, D_2, D_1, 6677, 7065.
	17	9 17	2		19	E	10	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8. 5363·0, D_2, D_1.
	18	8 39	2		19	E	10	5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, D_2, D_1.
	24	8 38	3	1·5		E	20	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5276·2, 5316·8, 5363·0, D_2, D_1.
October	7	9 15	3		12·5	E	10	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5270·0, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	11	9 13	2	12		W	10	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5270·0, 5363·0, D_2, D_1, 6677, 7065.
	15	9 24	3		20·5	W	15	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1.
	18	9 15	3		21·5	E	5	Faint D_2, D_1.
	20	8 41	4		14	W	10	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5368·0, D_2, D_1.
November	9	9 50	1		1·5	E	10	4924·1, 5016, 5018·6, b_4. b_3, b_2, b_1, 5234·8, 5276·0, 5316·8, 5363·0, D_2, D_1.
	16	11 50	2		16	W	10	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·0, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	22	9 5	5	10·5		W	15	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5270, 5316·8, D_2, D_1, 6677, 7065.
December	5	9 1	2	14		W	10	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5363·0, D_2, D_1, 6677.
	6	9 15	3		3·5	E	15	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	10	9 4	4	8		E	10	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677.
	11	9 2	3	11·5		W	20	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1.
	18	10 26	2	18		W	10	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·0, 5316·8, 5363·0, D_2, D_1.
	20	10 13	2	12		E	15	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	21	8 56		20		E	10	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5276·2, 5316·8, D_2, D_1.
	21	8 58	4	14		E	15	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.

The distribution of metallic prominences was as follows :—

	1°—10°	11°—20°	21°—30°	31°—40°	Mean latitude.	Extreme latitudes.
North	5	9	...	...	11·2	1°·5 and 20°·0
South	4	5	2	...	12·7	1°·5 and 21°·5

Fourteen were on the east limb and 11 on the west limb.

Displacements of the hydrogen lines.

Particulars of the displacements observed in the chromosphere and prominences are given in the following table.

TABLE III.—DISPLACEMENTS OF THE HYDROGEN LINES, JULY TO DECEMBER 1929.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1929.		H.	M.	°	°		A.	A.	A.	
July	2	9	41		7	W	1·5			At top.
	3	9	14		25	W	Slight			At base of the floating prominence; extends over 4° from 23° to 27°.
	3	9	21		18	W	0·5			At top; extends over 3° from 20° to 23°.
	3	9	23		2·5	W		2		At top.
	3	9	26	17		W	Slight			Do.
	4	9	21	11		E	1	2		At base.
	4	9	7		15·5	W	0·5			At top.
	4	9	0	7·5		W		1		Do. ; extends over 3° from 6° to 9°.
	4	8	49	32		W	1			At base; extends over 4° from 30° to 34°.
	14	10	7		54·5	W		1		At base.
	14	10	5	5		W	0·5			At top.
	15	9	14	7		E	0·5			Do.
	17	12	25		6	W			1	At base.
	18	8	49	16		W		0·5		Do.
	20	11	20	7		E			1	
	20	9	23	18		W	0·5			At base.
	24	9	46	21		W		1·5		Do.
	28	8	15	10		W	1			At top.
	29	12	16		23	W	1			Do.
	30	11	24		4	E		1		At base.
	31	8	50		5	E		1		At top.
August	1	8	50		20	W	0·5			Do.
	4	8	50	54·5		E	0·5			At base.
	5	9	38		23	W	1·5	1		To red at top; to violet at base.
	5	9	44		23	E	1·5			At base.
	6	8	31		68·5	W	1·5			At top.
	6	8	25	57·5		W		0·5		In chromosphere.
	8	14	51	0·5		E	1			
	8	15	3		18	W		Slight		At base.
	9	9	37	24		E	0·5			At top.
	9	9	39	7·5		E	1			Do.
	11	8	55	49		W	1			Do.
	11	8	54	54		W		Slight		At base.
	12	8	44		12	E	0·5			At top.
	12	8	37	3		W		0·5		
	13	9	24	57		E	0·5			At base.
	13	9	28	5		E	1			Do.
	14	8	50		8	W	1	1		To red at top; to violet at base.
	14	8	50		5	W	1·5			At top.
	14	8	43	8		W		0·5		At base.
	19	9	59	30		W		Slight		
	22	11	12		22	W	2			At top.
	24	10	10	28		W	1·5			Do.
	25	8	48	72		W	0·5			Do.
	27	9	20	9		W	Slight			Do.
	27	9	2	48		W		1		Do.
	30	9	5		7	W	1·5			Do.
	31	9	25	28		E	1			At top; extends over 4° from 26° to 30°.
	31	9	28	1·5		E	2			Extends over 3° from 0° to 3°.
	31	9	7		16	W		0·5		At base.
September	1	9	13	30		E		1		At top.
	1	9	8		16	W	Slight			Do.
	2	8	42		54·5	W		Slight		
	2	8	39	28		W	0·5			At top.
	3	9	0	25		E		0·5		At base.
	4	8	43	57·5		E	0·5	1		To red at base; to violet at top.
	5	9	40		7	W	3			At top; extends over 16° from +1° to —15°.
	5	9	40		3	W	6			At top (floating prominence).
	6	9	30	28		E		1		
	6	9	6	11		W	1			At top.
	9	8	44	7		E		0·5		Do.
	10	9	8	44		E	Slight			Do.

D t		Hour I.S T		Latitud		Limb	Displ m nt			R marks
				North.	S uth		Red	Vı l t	Both w y	
1929		H.	M				A	A	A	
Sept mbe	10	9	18	10		W	1	1 5		T d t t p to v ol t t base
	11	8	41		9	W		1		At bas
	11	8	39	5		W	0 5			At t p
	12	9	5	65		E	2			D
	12	9	6	38 5		E		Sl ght		At bas
	12	9	13	22 5		E	3	2 5		T d t t p; to l t at base
	12	8	56		43	W	0 5			At t p
	1_	8	46	12		W	1			At t p xt nds o er 4 fr m 10 to 14
	13	9	14		8	E			2	At b
	13	8	49	7		W			Slight	
	13	8	40	68		W	2			At b se
	16	9	12	32 5		E	0 5			D
	16	9	6		10	E	1	1 5		T d at base to vı l t at top
	17	9	0		24	E	1			At bas
	18	8	32	41 5		W	Slight			At top
	19	9	13		26	W	1 5			At base
	19	8	52	60		W	0 5			Do
	20	14	58	3		E			Slight	
	20	15	17		33 5	W	0 5	1 5		T d t bas to vi let at top
	21	9	26		22 5	E	1 5			At top xtends o 3 fr m 21° to 24
	21	9	1		58 5	W		1		At t p
	21	9	0		50 5	W	2 5	1		T d t bas , to vi let t top
	21	8	46	58		W		1		Ext ds 3° fr m 57° to 60°
	22	8	42	42 5		W	1			At t p
	24	8	26	15		E	0 5			At b
	24	8	38	2		E	0 5			Do
	27	9	2		17 5	W	0 5			At t p
	28	11	20	13		E		1		
O tobe	1	8	49	34 5		E	1			At bas
	1	8	45	32		W	Slight			At top
	5	9	9	47		E	0 5			At top ; xtends o ı 3 from 46 to 49
	5	8	58		1	W			1	
	5	8	50	11 5		W	0 5			At top xtends e 5 f m 9 to 14
	5	8	43	52·5		W	1 5			At t p
	6	8	51	3		E	0 5			At bas
	6	8	45	20		W	1 5			At t p
	7	9	17		3	E	2			At bas
	7	9	15		12	E	0·5			D
	7	8	53	17		W	1 5			At top
	11	9	50	52 5		E	0 5			At b
	11	9	55		15 5	E			0 5	
	11	9	16	2		W	1			At t p xtends o er 4 from 0 to 4
	11	9	16	7		W	2			At top
	11	9	16	9		W		0 5		D
	11	9	14	12		W	1			Do
	14	8	39	5		E	0 5			At bas
	14	8	43		57 5	E	2			D
	15	9	15		8	W	0 5			D
	16	9	58		18	W		0 5		At t p
	16	10	12	81		W		1		D
	17	10	32		23	W		2		At bas
	17	10	3		20	W	1 5			D
	17	10	30		18	W	1 5			At top
	17	10	30		16 5	W		2		Do
	18	9	7	69·5		E	1 5			Do
	18	9	13	13		E	2			At b se
	18	9	14		8	E		2·5		At top ; extends o e 4° from 6 to 10°
	18	9	15		21	E	3 5			At top
	18	8	55		26 5	W	0·5			Do
	18	8	53		16 5	W	1 5			At t p xtends over 3° from 15 to 18
	18	8	46	8		W		1		
	19	8	45	23		E	1 5			At top
	19	8	40		3	W	0·5			At b se
	20	8	50	16		E	Slight			At top
	20	8	41		18	W	2	3		T ed at top to vi let at b se
	20	8	41		13	W	1	1 5		Do

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1929.		H.	M.	°	°		A.	A.	A.	
October	22	9	14		27	W	2	1		To red at top ; to violet at base.
	22	9	10	57·5		W	1			At top.
	23	10	6		27	W		Slight		Middle of prominence.
	23	10	14	25		W	1			At top.
	24	9	37	78		E	1·5			At base.
	24	9	45	13		E	0·5			At top; extends over 4° from 11° to 15°.
	24	9	26		15·5	W	1·5			At top; extends over 3° from 14° to 17°.
	24	9	25		11·5	W	2			At base.
	27	11	54		19	E	0·5			Do.
	28	9	0		34	W		Slight		Do.
	28	9	4		20	W	1			At top.
November	3	8	50	2		E	0·5			At base.
	8	11	52	12		E	0·5			At top.
	8	11	17		8	E	1			Do.
	9	9	57	11		E	1			Do.
	9	9	33		1	E	1			Do.
	9	10	12	5		W			2	
	9	10	12	8		W	3			At top.
	10	8	50	12		W	1·5	1		To red at top ; to violet at base.
	10	8	50	15		W		0·5		At base.
	16	11	50		19	W			2	
	18	8	44	17		W		0·5		At base.
	19	8	55	17		E		Slight		Do.
	20	9	30	14		E		Do.		At top.
	22	9	40	26		E	0·5			Do.
	22	9	40		17	E		1		At base.
	22	9	40		22·5	E	1·5			At top.
	22	9	10		15·5	W	1·5			Do.
	22	9	9	3·5		W	1			Do.
	22	9	8	8		W			1	
	22	9	5	13		W		3		
	22	9	0	26		W	1·5	1		To red at base ; to violet at top.
	25	9	0	20		E		1·5		At top.
	25	9	0	14·5		E	1·5			Over middle of prominence, extends over 5° from 12° to 17°.
	25	9	0	10		E	1			At top; extends over 6° from 7° to 13°.
	25	9	2	5		E	2·5			No prominence.
	26	9	10	22		E		1		At top.
	26	9	7	20		E	1			Do.
	26	9	8	15·5		E		1·5		Floating cloud; displacement extends over 3° from 14° to 17°.
	26	8	56		10	E		1		At top; extends over 4° from 8° to 12°.
	26	9	13		18	E		0·5		At top.
	27	11	56	16		E		Slight		Do.
	27	12	30	72		W	Slight			In chromosphere.
	28	9	26	13·5		E	1			At top.
	28	9	7	42·5		W	0·5			At base.
	29	10	10		13	E	1·5			
	29	10	11		30	E	1			At base.
	29	9	41	4·5		W	4	3		To red at top; to violet at base.
	29	9	18	4·5		W	1			At top.
	29	9	2	64		W	1			Do.
	30	10	23		1	E		1		Do.
	30	10	22		9	E	2			Do.
	30	9	40		14	E		2		Throughout the tall filamental prominence.
	30	10	7		36·5	W		2		At base.
	30	10	12		3	W		1		In chromosphere.
December	5	9	33	0·5		E		1		At top.
	5	9	34		3·5	E			1·5	
	5	9	35		16·5	E		1		At top.
	5	9	15		50	W	0·5	1		To red at base ; to violet at top.
	5	9	9		25	W	2			At top.
	5	9	0	12		W			1	
	5	9	40	37·5		W	0·5			At top.

Date		Hour IST		Latitude		Limb	Displacement			Remarks
				North.	South.		Red.	Violet.	Both ways.	
1929		H	M	°	°		A	A	A	
December	6	9	15		3	E	2	4		To violet at top ; to red at base
	6	9	6		21	W		2·5		At base
	6	9	4	15		W	2	1·5		To red at top , to violet at base
	7	9	50		3	E	1			At base.
	7	9	51		20	W	1·5			At top.
	7	9	44	7		W	4			Do
	7	9	44	14		W	1			Do
	10	9	4	10		E	2·5			At base
	10	9	10		2	E	1·5	0·5		To red at base , to violet at top
	10	8	55	12		W	0·5			At top
	11	9	2	12		W		2·5		Do
	12	9	13	6		W	1·5			Do
	13	8	58	15		E	0·5			At base
	13	8	54		23	W	1			At top
	14	9	17	3		E	5			At base
	14	9	13		26	W	1			At top
	16	9	0		15	E		1		Do
	16	8	50	20		W		Slight		At base
	17	9	9	10		E	Slight			Do
	18	9	27	13		E	2			Do
	18	9	21	18		E	1			
	19	9	4		1	W		1		At base
	19	8	56	69		E		Slight		Do
	20	10	11	21		E	1			Do
	20	10	13	12		E	1·5	2		To red at base ; to violet at top
	20	10	3		11	W	1	1·5		Do do.
	20	9	53		4	W		1		At base
	21	8	58		15	E	3·5	2		To red at base , to violet at top
	21	8	50		60	W	0·5			At base
	23	9	10		12	W	0·5			Do
	23	9	2		12	W	1·5			At top.
	23	9	4		2	W	1·5	0·5		To red at top , to violet at base
	23	9	0	22		W	1			At top.
	26	8	53	18		W	0·5			Do
	28	8	42	18		W	1			Do
	31	9	18	29		E	Slight			Do.
	31	9	20	3		E		2		Do

The total number of displacements was 250 as against 348 in the previous half-year and their distribution was as follows :—

Latitude		North	South.
1°—30°	...	106	96
31°—60°	...	25	13
61°—90°	...	9	1
	Total	140	110

East limb ...	104
West limb ...	146
Total ...	250

Reversals and displacements on the Sun's disc.

Three hundred and sixty-five bright reversals of the Hα line, 354 dark reversals of D_3 line and 74 displacements of the Hα line were observed during the half-year. Their distribution is given below :—

	North.	South.	East.	West.
Bright reversals of Hα	174	191	182	183
Dark reversals of D_3	167	187	177	177
Displacements of Hα	38	36	33	41

Fifty-two displacements were towards the red, 19 towards the violet and 3 both ways simultaneously.

Prominences projected on the disc as absorption markings.

Photographs of the sun's disc in Hα light were available from Kodaikanal and the co-operating observatories for a total of 183 days, which were counted as 178 effective days. The mean daily areas of Hα absorption markings (corrected for foreshortening) in millionths of the sun's visible hemisphere and their mean daily numbers are given below :—

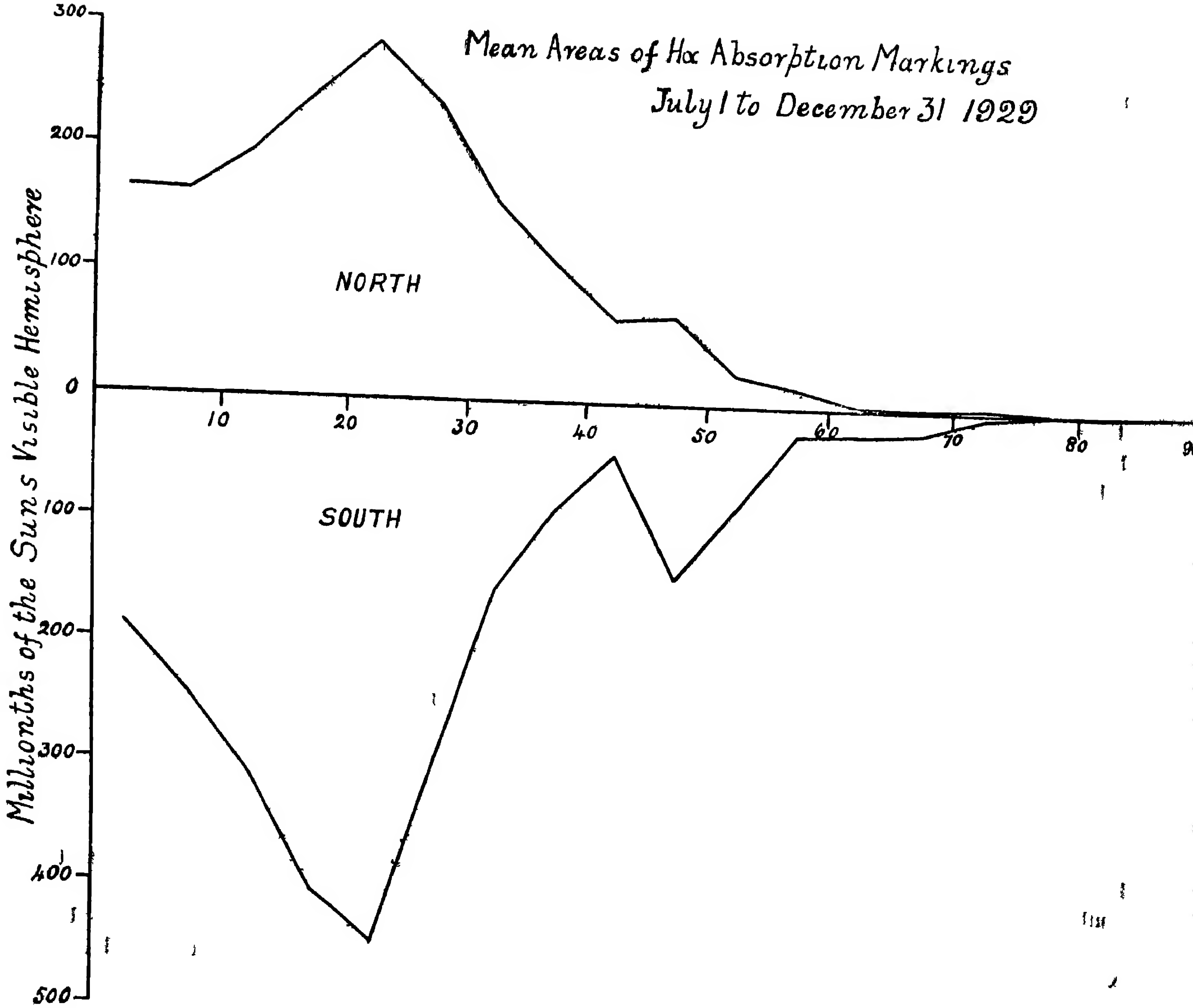
	Mean daily areas.	Mean daily numbers.
North	1,743	11·66
South	2,460	13·84
Total ...	4,203	25·50

The above show a decrease of about 5·1 per cent in areas and an increase of about 0·8 per cent in numbers compared with the previous half-year. The preponderance of activity has now shifted again to the southern hemisphere.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 140 days of observation being reckoned as 131 effective days.

	Mean daily areas.	Mean daily numbers.
North (Kodaikanal photographs only)	1,651	11·69
South (do.)	2,365	13·59
Total ...	4,016	25·28

The distribution of the mean daily areas in latitude is shown in the following diagram. The principal features of the latitude distribution are the maxima in the zones 20°—25° and secondary maxima at 45°—50°. Compared with the previous half-year there is a large decline from 35°—50° in the northern hemisphere, and near 40° in the southern hemisphere.



There is a slight excess of activity in the eastern hemisphere as regards areas and a slight defect as regards numbers the percentage east being 50 29 for areas and 49 26 for numbers

Thanks are due to the co operating observatories for the photographs supplied by them

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Hydrogen prominences

In 1928 a batch of panchromatic plates was received whose speed was considerably greater than that of previous supplies W th this new batch it was found that exposures in the Kodaikanal Hα spectroheliograph for the disc of the sun were only slightly longer than corresponding photographs in the calcium spectroheliograph using the K line and ordinary plates It was clear therefore that it would be practicable to obtain photographs of the solar prominences in hydrogen light with the Hα spectroheliograph which up to that time could only be used for disc photographs After making sure that the increased speed was not due to change but was maintained in subsequent supplies of fresh batches of panchromatic plates, it was decided to make

daily photographs of hydrogen prominences part of the regular programme commencing from January 1, 1929. The data for hydrogen prominences for the first and second halves of the year 1929 are given below in the present bulletin and will hereafter be included in the regular half-yearly bulletins.

The Hα prominence plates have proved especially valuable on those days when the sky is very hazy on account of the presence of cloud, for it is then found that the Hα spectroheliograph will show prominences which are completely obscured in the K spectroheliograph. This effect is largely to be attributed to the instrumental differences in the two spectroheliographs, for in the K instrument there is a considerable amount of scattered light which helps the obliteration of prominences when observing conditions are not good.

The mean daily areas of Hα prominences for each half of the year 1929 are given below together with the corresponding areas for calcium prominences collected here for convenience of reference.

	Mean daily areas (square minutes)	
	Hα prominences.	K prominences.
First half of 1929.		
North	1·31	2·46
South	1·43	2 52
Total ...	2·74	4·98
Second half of 1929.		
North	0·88	2·09
South	1·68	2·86
Total ...	2·56	4·95

The distribution of Hα prominences in latitude is very similar to that of K prominences as might have been expected. It will, however, be noticed that the mean daily areas of Hα prominences are considerably less than those of K prominences. In the first half the Hα prominence areas are only 55 per cent of the K areas and in the second half 52 per cent. This is not necessarily to be interpreted as evidence that the hydrogen prominences are less extensive or less high than calcium prominences. There are innumerable examples where individual prominences are identical in shape, height and area in the Hα and the K photographs. There is, however, considerable evidence that in the fainter and more scattered parts of K prominences the Hα counterpart is relatively much fainter when compared with the brighter parts of the prominence. This is not merely a photographic effect caused by the underexposure of the Hα plate, for whilst the main part of a prominence may be stronger in the Hα photograph than in the calcium, the reverse is often true in the fainter parts of the same prominence. The exact relations between the relative intensities in different parts of Hα and K prominences appear worthy of detailed study.

There are also instrumental reasons why the total Hα areas must be slightly smaller than the K areas. In the Hα spectroheliograph, the field of view outside the sun's limb is not so large as in the K spectrehelio-graph ; the upper parts of some high prominences are therefore missing in the Hα plates. The effect of such instrumental differences over a half-year is believed to be small.

It is noteworthy that the southern preponderance in the second half of 1929 is more marked in Hα prominences than in K prominences, the ratio of northern prominences to southern being 0·52 in Hα and 0·73 in K. It remains to be seen whether a similar difference is maintained in subsequent years.

THE OBSERVATORY, KODAIKANAL,
16th August 1930.

T. ROYDS,
Director, Kodaikanal and Madras Observatories.

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Kodaikanal Observatory.

BULLETIN No. LXXXIX.

THE ROTATION OF HYDROGEN ABSORPTION MARKINGS AND THEIR HEIGHT ABOVE THE SURFACE OF THE SUN

Abstract.—The results in this paper are based on Kodaikanal Hα spectroheliograms during the years 1926—1929.

The speed of rotation of hydrogen absorption markings has been determined by measurements near the central meridian for successive rotations of the same marking. Near the equator the siderial rotation is 14°·55 per day, that is, nearly the same as for spots, but the polar retardation, although evident, is less than for spots (see fig. 1 and table I). The polar retardation evidences itself by a progressive increase in the slope of an absorption marking to the central meridian at each successive rotation (see figs. 2 and 3 of plate).

The heights of hydrogen absorption markings have been deduced from the time required for a marking to pass from the eastern limb of the sun to the central meridian or from the central meridian to the western limb. This time has been termed the quadrantal time of the marking. Since an absorption marking usually cuts the limb of the sun at quite definite latitudes, the quadrantal times at these latitudes can be determined with exactness. If the height of an absorption marking above the sun's surface were zero, its quadrantal time would be that required for a quarter rotation (synodic) of the sun, but the quadrantal times are actually found to be less than the latter as a result of the height of the absorption markings above the surface of the sun. For the edge of the absorption markings nearer the limb the average quadrantal time is 5·55 days, and for the edge farther from the limb 5·65 days, compared with 6·82 days for a quarter rotation (synodic) of markings. The deduced heights of the two edges are 33″·5 and 28″·0 respectively, the average height of the prominences (Ca) at the limb being 46″. Consequently it follows that the lowest parts of prominences do not show on the disc by absorption. The lowest parts of prominences are believed to show on the disc only by emission, being represented by the bright margins at the edges of absorption markings and the centre of bright margins appears to have a height of about 12″, deduced from the quadrantal time of 6·1 days. As the average heights of prominences at the limb includes the finest detail of prominences it is not surprising that these heights are greater than the heights found for the absorption markings.

The level of Hα spectroheliograms is found to be 6″·3, or 4,590 kms. above the photosphere. This is the level of the chromosphere, and all the heights obtained in this paper are consequently to be understood as heights above the chromosphere.

The rotation of calcium absorption markings (filaments) has been studied by L. d'. Azambuja[1] who interpreted the apparent acceleration of rotation near the limb of the sun as an effect of the height of markings above the surface of the sun, and he estimated their heights accordingly. There can be little doubt that his interpretation is correct.

A study of this effect has now been made making use of the Kodaikanal spectroheliograms for the four years 1926--1929, taken with the Hα line. The method of measurement from which the heights of the absorption markings are deduced differs from that of d' Azambuja who measured the varying longitudes* of markings as they crossed the sun's disc. I find that longitudes near the limb of the sun cannot be measured accurately since a small error in a position near the limb leads to a considerable error in the deduced longitude. But it is here, near the sun's limb, where the apparent acceleration of rotation is greatest and where it is most desirable to know the longitudes and just here where the longitudes are subject to the largest errors. Moreover with such measures it is not simple to co-ordinate the results of different markings since they cannot be measured all at the same selected longitude, but have to be taken where they are found on photographs taken generally at daily intervals.

[1] L. d' Azambuja, Comptes Rendus, 176, 950, 1923.

* Longitudes measured from the central meridian are invariably meant in this paper.

An examination of figs 4—8 of the plate accompanying this bulletin will show that hydrogen absorption markings at the limb cut the latter at quite definite latitudes. It is a simple matter to measure these latitudes with sufficient accuracy. The time when these latitudes reach the central meridian of the sun can be accurately deduced from photographs taken when the absorption marking is near the central meridian since the errors of longitude are then small. The method used in this paper has consequently been to measure the time interval required for an absorption marking to travel from the east limb of the sun to the central meridian and from the central meridian to the west limb. It is convenient to have a name for these time intervals and they will be referred to as "quadrantal times" since they are the times required to traverse a quadrant of the sun. The quadrantal times for different markings in the same latitude zone can be immediately compared. There are naturally some disadvantages in the method in that it does not give as many chances of measurement as are available on the disc near the limb but it possesses a very great advantage that the necessary measures can be made very rapidly and sufficient accuracy can be obtained with comparative ease. The virtue of the method adopted in this paper lies in the fact that absorption markings are generally inclined to a meridian of the sun so that photographs taken at daily intervals will generally catch a marking cutting the limb at one place or another along the length of the marking; usually the absorption marking cuts the limb (or otherwise expressed the limb cuts the marking) in different places on two or more successive days. The only difficulty is with the few markings which lie along a meridian of the sun; such markings near the limb on one day will be completely past it on the next day, but the number of markings not caught in this way is small and their neglect will not appreciably affect the result.

The quadrantal times so obtained will be an index of the heights of the absorption markings. If the height above the sun's surface is zero the quadrantal time will be equal to the time required for a quarter rotation of the sun. The greater the height of the marking the less will be the quadrantal time.

The Level of Hα Spectroheliograms

We have hitherto spoken of the heights of absorption markings above the surface of the sun without specifying which surface exactly is meant. In deriving the heights we have only used the central meridian of the sun, which is the same for all levels, and the limb of the sun in Hα light.* The level of the surface to be considered is therefore the level of the limb of the sun in Hα light. The height of this above the photosphere can be measured by comparing the diameters of the sun in Hα light and in light from the adjacent continuous spectrum.† The diameters found are 60·03 mm for Hα images and 59·64 mm for the continuous spectrum. The deduced height is 6″·3 or 4,590 kms above the photosphere; that is probably identical with the top of the chromosphere which in calcium light has an average thickness of 5,000 kms.‡§ Consequently the surface of the sun which has been considered in this paper is the upper surface of the chromosphere and the heights which are deduced for absorption markings etc are heights above the chromosphere.

Mean Rotational Speed of Hα Absorption Markings

The true speed of rotation of absorption markings can be obtained from measurements near the central meridian where the height is so much foreshortened that its effect is inappreciable. Day to day measures are subject to the irregular movements of markings and the effect of errors of measurement would be appreciable.

* It is curi us that n n has m nti n d (far a I am aware) that the l mb of th sun in Hα l ght may ha e a double edge yet it is l arly in K daik nal sp tr h l ogr ms good d y. The us f th doubl dge f th sun disc is not instrumental in the n f being d t astigm tism o th ptical def ct f th p tr h l graph but is instrumental being probably du to th fact that th spectroh li graph mploys a fixed width f th se ond l t n the arrow ... structure of th Hα lin at the limb. The s paration of the tw dges in Kodaikan l H spectr h l grams is about ... varying somewhat in diff r nt pl ces.

† D Azambuja has also used this m th d fo determining l l f sp t h l gr m but ot for Hα. M udon Annales tome VIII fas II 1930.

‡ St John Astr phys al J urnal 32 36 1910.

§ Abetti howe er find th thi knes f th hydrog n hromoshper to be fr m 9″ t 10″. Ob rvat ry 49 89 1926.

N

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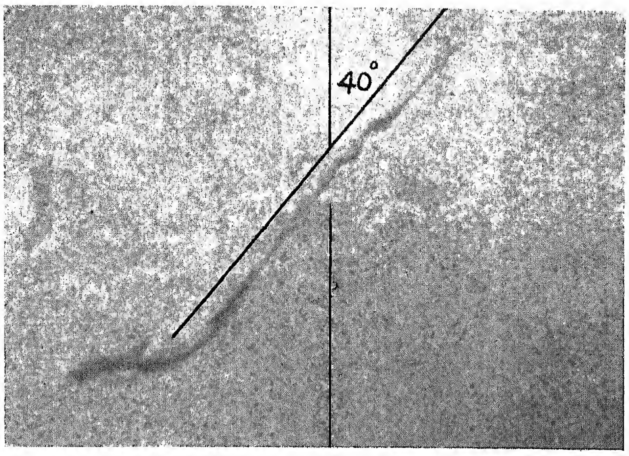

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Fig. 2. 1927 Aug. 2, 3^h 51^m G.C.T. Compare with fig. 3 below.

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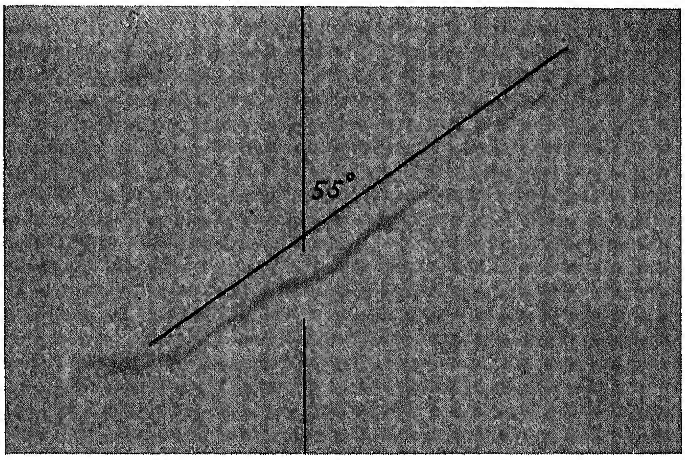

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Fig. 3. 1927 Aug. 29, 3^h 00^m G.C.T.

This is the same dark marking as fig. 2 after a complete rotation of the sun. The slower speed of rotation in higher latitudes shows by the increased slope of the marking to the central meridian which is indicated by the vertical line.

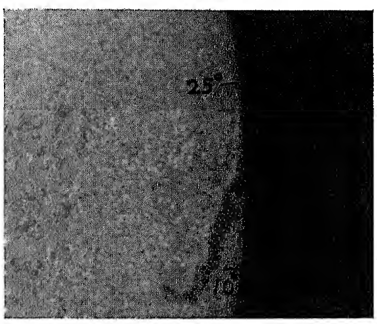

Fig. 5. 1927 Aug. 28.
This is the same marking as figs. 2 & 3.

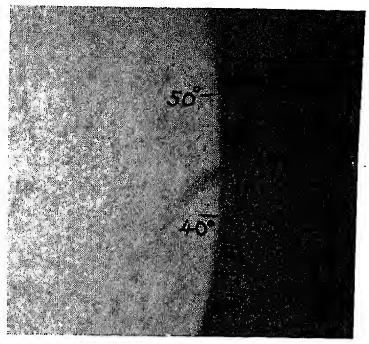

Fig. 4. 1927 Apr. 8.

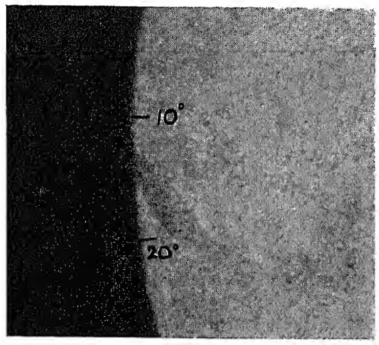

Fig. 6. 1928 Apr. 2.

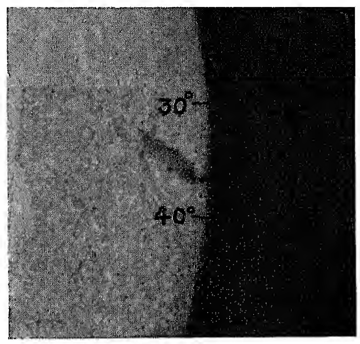

Fig. 7. 1928 Dec. 30.

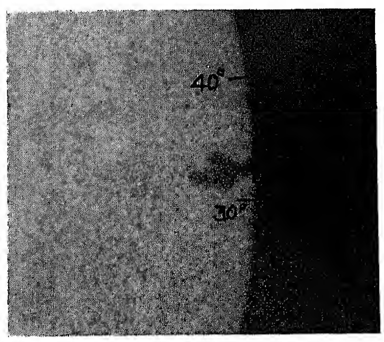

Fig. 8. 1929 Nov. 30.
Figs. 4 to 8 are examples of dark markings which have been measured at the limb.

This line represents the length of the solar diameter on the scale of the photographs.

All the photographs are positives.

It is best therefore to consider only absorption markings which have existed through a complete rotation of the sun and to find the times required for a complete rotation from the central meridian to central meridian. All markings in the years 1926—1929 which have crossed the central meridian more than once were measured. Measures were made on the western (or preceding) edge of the absorption markings for the sake of definiteness but no difference to the result would be caused by taking the centre or the eastern edge of markings. From photographs showing an absorption marking near the central meridian the times of actually crossing the central meridian were deduced for intervals of 5° of latitude, assuming the approximate value of 13° per day for synodic rotation to reduce the positions near the central meridian to the actual time of crossing it. Not many measures are possible in the belt between 0° and 5° owing to the paucity of markings of long duration; beyond latitude 40° most markings are parallel to the equator and the speed of rotation of such markings cannot be measured with accuracy. The results do not vary greatly from marking to marking in the same latitudes, nor from year to year. They are given below in table I.

TABLE I.—MEAN ROTATION OF Hα ABSORPTION MARKINGS.

										Means of all
Latitude	0°	5°	10°	15°	20°	25°	30°	35°	40°	21°·9
No. of markings ...	3	11	19	37	47	40	30	23	6	
Days for complete synodic rotation.	26·54	26·68	26·94	27·02	27·22	27·38	27·54	27·81	27·86	27·27
Degrees per day (synodic), ξ'.	13·56	13·48	13·36	13·31	13·22	13·14	13·07	12·94	12·91	13·20
Degrees per day (sidereal), ξ.	14·55	14·47	14·35	14·30	14·21	14·13	14·06	13·93	13·90	14·19

Fig. 1.—Rotation of Hydrogen absorption markings compared with Sunspots.

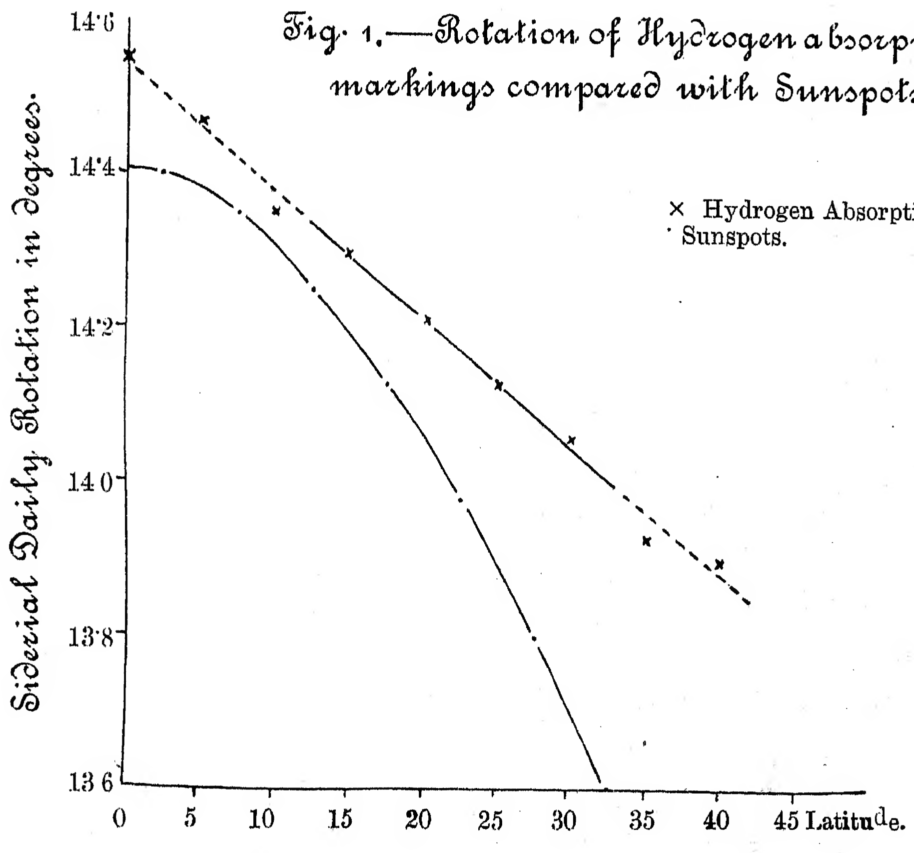

Fig. 1 shows the curve of variation of siderial rotation with latitude compared with the rotation of sunspots, taking for the latter the unweighted means of Carrington, Spoerer and Maunder[1]. It will be seen that although the rotation of absorption markings in low latitudes approximately agrees with that of sunspots, in higher latitudes their rotation is more rapid. The retardation of rotation in higher latitudes is however clearly marked. This is well illustrated in figs. 2 and 3 of the plate. Fig. 2 shows a long straight absorption marking stretching from latitude 7° N. to 35° N. near the central meridian on 1927, August 2 at $3^h\ 51^m$ G.M.T. The central meridian is indicated by a vertical line, and a line inclined to it at an angle of 40° is roughly parallel to the marking. If the higher latitudes are rotating more slowly than lower latitudes, they will gradually lag behind and increase the inclination of the marking to a meridian. This is neatly shown in fig. 3 in which is reproduced the same marking as fig. 2 after one complete rotation of the sun, again near the central meridian on 1927, Aug. 1929 ; the line drawn at 55° to the central meridian indicates how much the inclination of the marking has increased since August 2 on account of the retardation of rotation in higher latitudes.

The above noted increase in the inclination of absorption markings with increasing age lends support to the idea put forward in a previous bulletin[2] that the greater inclination in higher latitudes is caused by the retardation of rotation there.

Heights of Hydrogen Absorption Markings.

We are now ready to proceed with the determination and use of the quadrantal times of absorption markings, defined above as the time required for a point on a marking to pass from the east limb to the central meridian or from the central meridian to the west limb.

An example of the method of working may be given from figs. 3 and 5 of the plate. The eastern edge of the filament in fig. 5 cuts the east limb at latitude 16° N. at the time of the photograph, namely $3^h\ 26^m$[*] G.M.T. on August 23rd. The same marking is shown near the central meridian in fig. 3 at $3^h\ 0^m$ G.M.T. on August 29th ; measurement shows that latitude 16° N. on the eastern edge of the marking was 3° W. of the central meridian at this time and therefore would have been actually on the central meridian 5 hours and 30 minutes before the photograph was taken. Consequently the time interval between the limb and the central meridian was from $23^d\ 3^h\ 26^m$ to $28^d\ 21^h\ 30^m$, that is $5^d\ 18^h\ 4^m$, or $5^d{\cdot}75$ for the quadrantal time at latitude 16° N.

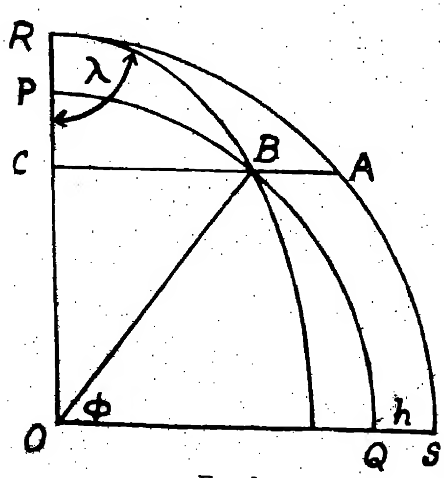

Fig. 9.

In fig. 9, *PBQ* represents the east limb of the sun from the pole *P* to the equator. *OP* is the central meridian of the sun and *OQ* the equator. Let *A* be a point above the limb at height h above the surface of the sun, whose radius is a. *A* rotates with a known speed until it reaches the limb of the sun at the point *B*, and has still to rotate through an angle which is denoted by γ before reaching the point *C* on the central meridian.

The angle λ is measured by the quandrantal time in days multiplied by the angle through which *A* rotates (synodically) in 1 day. Denote the latitude of *B* by ϕ. We require an equation connecting h and λ. Since h/a and $\cos^2\lambda$ are small compared with unity for the heights to be considered, the relation

[1] Hale, Astrophysical Journal, Nos. 27, 213, 1908.

[2] Royds, Kodaikanal Observatory Bulletin, No. 63, 1920.

[*] In the actual working all times were reduced to decimals of a day reckoning from a convenient zero hour. Since most photographs are taken between 8^h and 9^h I.S.T., 8^h was made the zero hour as being more convenient than midnight.

between the height of the point A above the sun's surface and the quadrantal time can be expressed in the form

$$\frac{2h}{a} = \cos^2\lambda.\ \cos^2\phi$$

The effect of the inclination of the sun's equator to the ecliptic is small and has been ignored.

Since the majority of absorption markings are inclined to the meridian with the lower latitude end more westerly than the higher latitude end, [1] it follows that the eastern edge of such a marking cuts the limb (either east or west) at a lower latitude than the western edge. The reverse is true for those exceptional markings whose inclination is in the opposite sense to the majority, and such cases were carefully distinguished. It was soon found that the east quadrantal times are less for the eastern edge of an absorption marking than for the western edge, and the reverse is true for the west quadrantal times. In the following table II, the east quadrantal times for the eastern edges and the west quadrantal times for the western edges have been grouped together under "edge nearer the limb" and similarly the east quadrantal times for the western edge and west quadrantal times for the eastern edge have been grouped under "edge farther from the limb". The daily synodic rotation ξ', has been interpolated from table I, and λ is obtained by multiplying this by the previous column. The heights h were deduced by the formula of the previous paragraph.

TABLE II.—QUADRANTAL TIMES FOR Hα ABSORPTION MARKINGS AND THEIR CORRESPONDING HEIGHTS.

Latitude.	Number of markings.	Edge nearer the limb.				Edge farther from the limb.			
		Quadrantal time in days (T_1)	ξ'	λ	Height h_1.	Quadrantal times in days (T_2).	ξ'	λ	Height h_2.
			°	°	″		°	°	″
0— 5	6	5·45	13·50	73·6	38·4	5·47	13·50	73·8	37·1
6—10	12	5·30	13·42	71·2	48·5	5·42	13·42	72·9	41·0
11—15	19	5·59	13·33	74·5	32·6	5·74	13·33	76·5	25·2
16—20	29	5·54	13·25	73·4	36·0	5·66	13·25	75·0	29·4
21—25	26	5·62	13·17	74·0	31·2	5·76	13·17	75·9	23·8
26—30	35	5·48	13·08	71·7	37·2	5·62	13·08	73·5	30·5
31—35	38	5·57	13·00	72·5	30·5	5·69	13·00	74·0	25·8
36—40	27	5·60	12·92	72·4	27·3	5·67	12·92	73·3	24·7
41—45	15	5·48	12·84	70·4	28·9	5·51	12·84	70·7	28·4
° 27·3*	...	Weighted means. 5·555	...	...	″ 33·5	Weighted means. 5·650	...	...	″ 28·0

As seen in the above table, the mean height of the highest portion of an absorption marking is 33″·5 and the height of the lowest portion is 28″·0. The average height of all prominences at the limb (in Ca K light since Hα photographs are not available) is 39″·4, but it is to be remembered that all prominences are not represented in the markings chosen for measurement. The mean height of the prominences corresponding to the markings measured is about 46″. Considering however that such heights include all the fine details seen in prominences it is not surprising that the fine details may not contain sufficient hydrogen to show by absorption when on the disc of the sun.

A surprising result is that the height of the lowest portions showing by absorption is 28″·0, only 5″·5 lower than the highest portions. A greater difference had been anticipated, indeed a value approximating to zero for the height of the lowest portion had been expected, quite unjustifiably, as a brief examination of

[1] Kodaikanal Observatory Bulletin, No. 63.

* Corresponding to the weighted mean of $\cos^2\phi$

spectroheliograms will show that the quadrantal times of the two edges of an absorption marking are only slightly different. This result is not to be supposed as possibly due to an erroneous value of the speed of rotation of absorption markings. No reasonable modification of the law of rotation can make the height of the edge of an absorption marking which is farther from the limb approach to zero. Hence there can be no doubt that a hydrogen absorption marking does not represent the whole of a prominence from base to summit, nor does it represent the lower portions only, but on the contrary only represents, in the average, a region of the prominence between 28″·0 and 33″·5 in height. Where then is the lower part of the prominence when the rotation has carried the prominence on to the face of the sun? An answer to this question is suggested in a later paragraph.

The above result that a hydrogen absorption marking represents such a narrow section of a prominence at the limb accounts for two observed facts. If the lowest part of an absorption marking were really at the zero level, we should expect the maximum height of the attendant prominence when this lower edge of the marking cuts the limb. As a matter of fact the greatest height of a prominence is nearly always one day earlier at the east limb and one day later at the west limb, than when the absorption marking cuts the limb. The second fact explained is the absence of any close relation between the shape of an absorption marking near the limb and the shape of the prominence at the limb. The reason is clear since the absorption marking proves to correspond to only a small section of the prominence.

It will be seen from table II that the quadrantal times do not vary appreciably with latitude but that the deduced heights are somewhat smaller in higher latitudes. The deduced heights depend on the two factors, $\cos^2\lambda$ and $\cos^2\phi$, the latter of which is chiefly responsible for the variation of heights with latitude. A modification of the law of rotation of absorption markings would however alter the variation of heights with latitude as the angle λ would be affected.

Table III shows that the quadrantal times diminish steadily from 1926 to 1929, i.e., the deduced heights are increasing. Whether this is a real effect or is in some way due to the selection of markings for measurement cannot now be said.

TABLE III.—VARIATION OF QUADRANTAL TIMES OF Hα ABSORPTION MARKINGS AND THEIR CORRESPONDING HEIGHTS IN SUCCESSIVE YEARS.

Year.	Edge nearer the limb.		Edge farther from the limb.	
	Quadrantal time in days (T_1).	Height h_1.	Quadrantal time in days (T_2).	Height h_2.
		″		″
1926	5·627	30·0	5·738	24·7
1927	5·542	34·2	5·658	28·3
1928	5·499	36·2	5·580	31·9
1929	5·392	40·7	5·508	35·6

If, as the above reasoning has shown, a hydrogen absorption marking represents only an upper part of a prominence seen at the limb, it seems pertinent to enquire whether the lower parts of a prominence at the limb are seen at all when on the face of the sun. The only feature attached to a hydrogen absorption marking besides the marking itself is the bright margin on each side of the dark absorption. It has been pointed out[1] that practically every hydrogen dark marking is accompanied by bright margins on each side. It was shown that as the dark marking approaches the sun's limb, the bright margin on the side farther from

[1] Kodaikanal Observatory Bulletin, No. 63.

the limb becomes relatively brighter, whilst the bright margin on the limb side disappears through being hidden from view by the higher dark marking. The method adopted at that time to give the height of the dark absorption above the bright margin could not be expected to give more than the order of magnitude of this height, and the difference of height found was 10″. It is now found possible to determine the height of the bright margin somewhat more precisely from their quadrantal times, exactly as has been done for the dark absorption. Notwithstanding the fact that most dark markings are accompanied by bright margins, yet not often do the margins make a clear cut on the limb of the sun. Not many can therefore be measured and the measures are not so definite as for absorption markings. An example is shown in fig. 5 of the plate; it is hoped that the reproduction will show the bright margin on the side farther from the limb, cutting the latter farther north than the absorption marking. In the four years 1926—1929, only 20 bright margins were considered suitable for measurement without ambiguity. Measurements were made on the middle of the place where the bright margin touches the limb of the sun and the results are given below in table IV.

TABLE IV.—QUADRANTAL TIMES AND CORRESPONDING HEIGHTS OF THE BRIGHT MARGINS OF Hα ABSORPTION MARKINGS.

Mean latitude.	Number.	Quadrantal times in days (T_3).	λ	Height h_3.
21°·4	20	6·09 days	80°·4	11″·6

The mean height deduced is 11″·6, or about 16″ below the absorption marking which may be compared with 10″ for the order of magnitude deduced in the previous bulletin referred to above. Considering the fact that it is only practicable to measure the middle point of the width of the bright margins and this has a height of 11″·6, it seems reasonable to suppose that the lowest portions of the bright margin must be almost, if not quite, on the surface of the chromosphere.

The above deduced heights for the different parts of an absorption marking do not give a complete explanation of the relation between an absorption marking on the disc and the prominence seen at the limb, but they do throw some light on it. We have prominences at the limb extending to an average height of, say, 46″. The highest part of the corresponding absorption marking is 33″·5 above the chromosphere and the lowest 28″·0. The light used in obtaining the spectroheliograms is the centre of the Hα line whose fluctuations of intensity give us the well-known features of Hα spectroheliograms. These fluctuations may be due to (1) fluctuations in the photospheric light seen through a partially transparent layer of hydrogen, (2) fluctuations in the number of absorbing atoms in the partially transparent layer of hydrogen, or (3) fluctuations in the emission and absorption of layers of hydrogen completely opaque to the photosphere below. Since the prominences on the disc have no counterpart in the continuous spectrum we can exclude (1) above. Also, if (2) were effective, the bright margins of absorption markings would have to be interpreted as due to less absorption of photospheric light due to the removal of absorbing atoms either bodily or by excitation. It is unreasonable to suppose that the presence of a prominence can lead to a diminution of the number of atoms capable of absorbing the Hα line. We are therefore driven to (3), namely that the brightening of the Hα line in a bright margin is due to brighter emission of the hydrogen itself and that the absorption marking is due to the absorption of light from this background by the cooler layer of hydrogen. The lowest parts of prominence then correspond to the bright emission seen at the margins of absorption markings but probably also underlying the whole absorption marking. They are radiating more strongly than the general surface of the sun (in Hα light) but are not much raised above the surface of the chromosphere. Since the total width of the bright margins (assumed to underlie the absorption marking) is greater than that of the absorption

marking it follows on the above interpretation that the lower parts of the prominence are more extensive than the upper parts which is reasonable Absorption of this bright background can only be exerted by those higher portions of the prominence which are cool This absorption begins at a height of 28 0 (on the average) and extends to a height of 33 5 The parts of a prominence above this height are supposed not to contain sufficient absorbing atoms to effect appreciable absorption and are therefore not represented in the absorption marking It must be stated nevertheless that the edges of an absorption marking are generally quite sharp and unless we can see a reason why absorption should suddenly begin at a definite height so as to cause a sharp edge we must seek the cause in the build or structure of prominences

It must not be supposed without further examination that results obtained in this bulletin for hydrogen absorption markings apply equally to calcium absorption markings The two kinds of absorption markings may have somewhat different structures In the first place I believe I am correct in saying that K_3 absorption markings are not accompanied by bright margins similar to those in the case of hydrogen It is also possible, if not probable that the heights deduced from measures of K_3 absorption markings would not be identical with those of Hα absorption markings Further Evershed has shown [1] that in calcium prominences the gases at a height of 29 are moving westwards at about 1 km/sec faster than the prominences themselves; if this movement s shared by hydrogen then in an absorption marking such as that illustrated in fig 3 the hydrogen must have passed completely out of the marking in less than 2 hours The absorption marking illustrated in fig 3 has a fairly typical width in round figures 6 000 kms and if the hydrogen in it is moving westwards at 1 km/sec it will have passed out of the marking in 6 000 secs or less than 2 hours as stated above Since absorption markings frequently last for months we would have to assume in such a case that the absorbing hydrogen must be continuously renewed from below

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[1] J E rshed M nthly N ti R A S 88 126 1927

KODAIKANAL,
22nd December 1930

T ROYDS
Director Kodaikanal and Madras Observatories

MADRAS: PRINTED BY THE SUPERINTENDENT, GOVERNMENT PRESS—1931.

Kodaikanal Observatory.

BULLETIN No. XC.

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE FIRST HALF OF THE YEAR 1930.

In pursuance of the programme of work adopted since 1st January 1923 under the auspices of the International Astronomical Union, all observatories taking spectroheliograms of the sun have been asked to co-operate with the Kodaikanal Observatory by supplying copies of their photographs on those days when the Kodaikanal records are imperfect or wanting. In response to our requirements for the first half of the year 1930, the Mount Wilson Observatory supplied calcium (K_{23}) prominence plates for 28 days and Hα disc plates for 14 days, Meudon Observatory supplied calcium (K_3) disc plates for nine days and Hα disc plates for thirteen days; the Pitch Hill Observatory (Mr. Evershed's) at Ewhurst, Surrey, England, supplied two Hα prominence plates and two Hα disc plates.

When only incomplete or imperfect photographs for any day are available from more than one observatory, the best photograph is chosen as representing the solar activity of that day after weighting it according to its quality, and the remaining photographs are ignored.

Calcium prominences at the limb.

The mean daily areas and numbers of prominences photographed during the half-year by means of the K line of calcium are given below. The means are corrected for incomplete or imperfect observations, the total of 179 days for which plates were available being reduced to 166½ effective days.

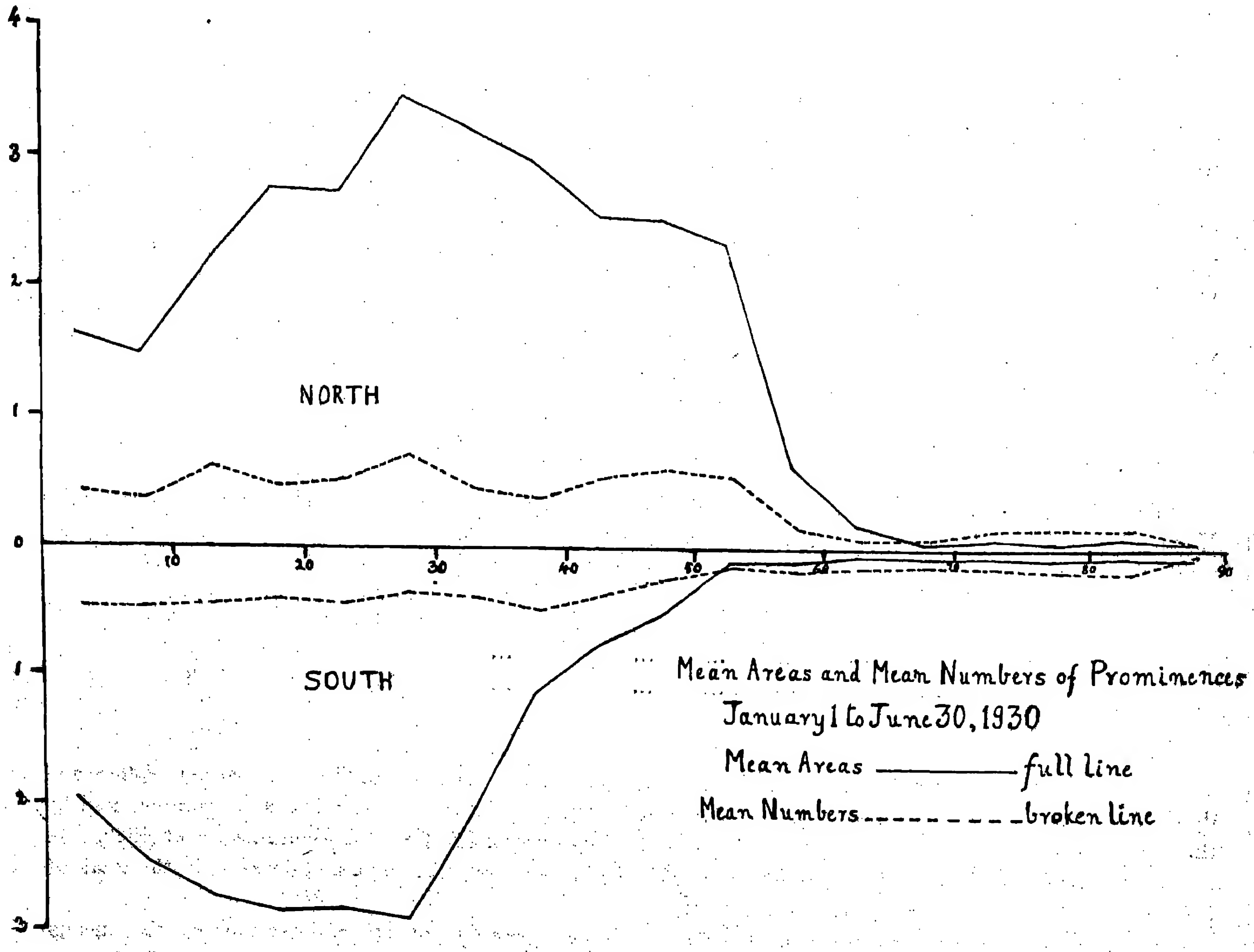
	Mean daily areas (square minutes).	Mean daily numbers.
North	2·90	6·52
South	2·07	5·03
Total ...	4·97	11·55

Compared with the previous half-year prominence activity has increased in the northern hemisphere and decreased in the southern. So far as areas are concerned the decrease in the south is exactly compensated by the increase in the north, leaving the total unchanged from those for the first and second halves of 1929. As regards numbers the decrease in the southern hemisphere preponderates giving a nett decrease in the total of 10·3 per cent below that for the second half of 1929.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 158 days of observation being counted as 145 effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North (Kodaikanal photographs only)	3·13	6·96
South (do.)	2·16	5·33
Total ...	5·29	12·29

The distribution of prominences in latitude is represented in the following diagram, in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude. The ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line. In the northern hemisphere the distribution is similar to that in the previous half year although the activity is greater ; in the southern hemisphere there is a notable decrease in activity in the region 35° to 70°.



The monthly, quarterly and half-yearly areas and numbers, and the mean height and mean extent of the prominences on photographs from all co-operating observatories are given in Table I. The unit of area is one square minute of arc. The mean height is derived by adding together the greatest heights reached by individual prominences and dividing by the total number of prominences observed ; the mean extent is derived by adding together the lengths of the base on the chromosphere of individual prominences and dividing by the total number of prominences.

TABLE I.—ABSTRACT FOR THE FIRST HALF OF 1930.

Months.	Number of days (effective).	Areas.	Numbers.	Daily means. Areas.	Daily means. Numbers.	Mean height.	Mean extent.
1930						″	°
January	28½	144·3	324	5·1	11·4	38·4	7·4
February	27¾	154·5	312	5·6	11·2	38·7	7·1
March	26½	125·5	362	4·7	13·7	33·7	5·9
April	28½	147·1	322	5·2	11·3	34·3	7·1
May	29	163·2	342	5·6	11·8	33·6	6·8
June ...	26¼	91·8	262	3·5	10·0	30·8	6·1
First quarter ...	82¾	424·3	998	5·1	12·1	36·8	6·8
Second quarter ...	83¾	402·1	926	4·8	11·1	33·0	6·7
First half-year ...	166½	826·4	1,924	5·0	11·6	35·0	6·7

Distribution east and west of the sun's axis.

Unlike the previous half-year, at the east limb there is an excess of areas but a defect of numbers as will be seen from the following table :—

1930 January to June.	East.	West.	Percentage East.
Total number observed	905·0	1,018·0	47·06
Total areas in square minutes	421·6	404·8	51·02

Hydrogen prominences.

During the half-year, photographs of the prominences in hydrogen light were taken in this observatory on 146 days which were counted as 137½ effective days. The mean daily areas in square minutes of arc of hydrogen prominences are given below :—

	Mean daily areas (square minutes).
North (Kodaikanal photographs only)	1·22
South (do.)	1·00
Total ...	2·22

The Hα areas are only 42 per cent of the calcium areas. Compared with the previous half-year Hα areas show a decrease of 13·3 per cent. The curve of distribution of Hα prominences in latitude is similar to that of calcium prominences. As in the case of calcium prominences the northern hemisphere now shows a greater activity than the southern, the ratio of the northern areas to the southern being 1·22 and 1·45 for Hα

and K prominences, respectively. It is thus seen that the northern preponderance is more marked in K prominences than in Hα prominences, the opposite being the case in the previous half-year.

Metallic prominences.

Thirty-one metallic prominences were observed during the half-year. Their details are given below :—

TABLE II.—LIST OF METALLIC PROMINENCES OBSERVED AT KODAIKANAL, JANUARY TO JUNE 1930.

Date.		Time. I.S.T.	Base.	Latitude. North.	Latitude. South.	Limb.	Height.	Lines.
1930.		H. M.	°	°	°		″	
January	17	10 55	3	20·5		E	15	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5316·8, 5363, D_2, D_1, 6677.
	20	8 43	7	10·5		W	10	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5316·8, 5363, D_2, D_1, 6677, 7065.
	28	9 9	2		19	E	15	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·0, 5316·8, 5363, D_2, D_1, 7065.
	30	10 0		24·5		E	15	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5316·8, D_2, D_1, 6677.
	31	9 19		15·5		W	10	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5316·8, D_2, D_1, 6677.
		9 18	2	20		W	20	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5316·8, D_2, D_1, 6677.
February	2	9 20			9	E		b_4, b_3, b_2, b_1, D_2, D_1. Faint.
	14	9 28	3	19·5		E	25	b_4, b_3, b_2, b_1, D_2, D_1. Faint.
	16	9 5	3		18·5	W	15	4924·1, 5016. 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363, D_2, D_1, 6677, 7065.
	20	9 10	2		11	W	15	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5198·9, 5208·8, 5284·8, 5268·8, 5270·6, 5276·0, 5276·2, 5284·2, 5316·8, 5328·1, 5363, 5371·7, D_2, D_1, 6677, 7065.
	23	9 38			12·5	E	10	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·0, 5316·8, 5363, D_2, D_1, 6677, 7065.
March	1	9 41			13	E	10	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363, D_2, D_1, 6677, 7065.
		9 41	1		16·5	E	10	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363, D_2, D_1, 6677, 7065.
	14	9 24	7		17·5	W	20	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5316·8, D_2, D_1, 6677.
		9 16	5	0·5		W	30	b_4, b_3, b_2, b_1, D_2, D_1 Faint.
	15	10 10	1	30·5		E	10	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363, D_2, D_1.
		10 10	1	26·5		E	10	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363, D_2, D_1.
		10 25	1	13·5		W	5	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363, D_2, D_1.
	25	10 6	1		29·5	W	10	b_4, b_3, b_2, b_1, D_2, D_1.
	30	9 8	3	18·5		E	10	b_4, b_3, b_2, b_1, 5316·8, D_2, D_1.
		9 2	3		11·5	W	30	5018·6, b_4, b_3, b_2, b_1, 5276·2, 5316·8, D_2, D_1.
April	1	12 22	3	13·5		E	10	b_4, b_3, b_2, b_1, 5316·8, D_2, D_1, 6677.
	8	9 52	7		21·5	W	20	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1.
	14	8 40	4	12		W	20	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1.
	18	9 2	3	18·5		E	20	b_4, b_3, b_2, b_1, 5316·8, D_2, D_1.
	20	9 0	2	9		W	15	b_4, b_3, b_2, b_1, D_2, D_1.
May	5	8 43	3		17·5	W	20	5018·6, b_4, b_3, b_2, b_1, 5276·2, 5316·8, D_2, D_1, 7065.
	18	8 50	4		15	E	20	5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, D_2, D_1.
	22	10 26	2	15		E	10	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5316·8, 5363, D_2, D_1, 6677.
	31	10 20	1	27·5		E		b_4, b_3, b_2, b_1, D_2, D_1.
June	5	8 55	3	10·5		W		4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5316·8, 5363, D_2, D_1, 6677.

The distribution of metallic prominences was as follows :—

—	1°–10°	11°–20°	21°–30°	31°–40°	Mean latitude.	Extreme latitudes.
North	4	10	4	...	17°·0	0°·5 and 30°·5
South	1	10	2	...	16°·3	9°·0 and 29°·5

Sixteen were on the east limb and 15 on the west limb.

Displacements of the hydrogen lines.

Particulars of the displacements observed in the chromosphere and prominences are given in the following table :—

TABLE III.—DISPLACEMENTS OF THE HYDROGEN LINES, JANUARY TO JUNE 1930.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1930.		H.	M.	°	°		A.	A.	A.	
January	1	9	8	4		E	1			At base.
		9	8	1		E		0·5		At top.
		9	10		6	E	0·5			At base.
	2	8	50	15		W	1			At top.
		9	0	15		W	3·5			Do.
	5	10	44	19		E		1		Do.
	6	9	7	63		E		1		At base.
		9	14	12		E	1	0·5		To red at top; to violet at base.
	11	8	52		4	E	0·5			At base.
		8	43	22		W	1·5			At top.
	12	9	31	28		E	1			At base.
		9	32	11		E		1		At top.
		9	12		77	E		Slight		Do.
	13	8	52	59·5		E	0·5			Do.
	14	10	15	14		E	0·5			Do.
	17	11	0		1·5	E		0·5		At base.
		9	20		6	W	3	1·5		Both at top.
	18	12	10	81		W		1		In chromosphere.
	19	9	11		30	W	1			At top.
		9	1		3	W	1			Do.
		9	0	3		W	0·5			Do.
	20	9	55	59·5		E			0·5	At base.
		10	2	10		E	1·5			At top.
		9	51		55·5	W		1		At base.
		9	51		48	W		0·5		Do.
		8	45	1		W	2			At top
	21	10	30	15		E	0·5			At base.
	22	10	12	55·5		E		1		At top.
		10	15	29		E	1			No prominence.
		10	20	15·5		E		1		At top.
		10	20	15		E	2			At top; extends over 6° from 12° to 18°.
		10	20	12		E		1		At top.
		10	5		32·5	W			1	Do.
		9	56	20		W		1		At base.
	23	9	9	14		E		0·5		Do.
		8	55	4		W		1		At top.
		8	51	13		W	0·5			At top; extends over 4° from 11° to 15°.
	24	9	17	11·5		E		2·5		At top; extends over 3° from 10° to 13°.
		9	4	9		W		0·5		At base.
	25	9	29	25		E	1			At top.
		9	25		3	E	3			No prominence.
		9	4	10		W	Slight			At top.
	26	10	28	36		E	1			At base.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1930.		H.	M.	°	°		A.	A.	A.	
January	26	10	29	25		E	Slight			At top.
	27	9	28	19		E	1			Do.
		9	33	2·5		E		2		At top; extends over 7° from −1° to + 6°.
		9	33	1·5		E	1			At base.
		9	10	26		W	2			At top.
		9	5	67		W		1		Do.
	28	9	39	53·5		E		Slight		Do.
		9	30	8		E	Slight			Do.
		9	10		19	E		1		Do.
	29	9	44	15		E		1		Do
		9	45	13		E	0·5			In a floating cloud.
		9	49	4		E	1·5			At base.
		9	29		19	W			2	On prominence.
		9	16	32		W		1		No prominence.
	30	9	45	24·5		E	1·5	1		To red at top; to violet at base.
		9	18	11		W	0·5			At base.
		9	9	76·5		W	1·5			At top.
	31	8	58	49·5		E		1·5		Do.
		9	43		8	E	1	1		To red at top; to violet at base.
		9	19	15·5		W	1			At base.
		8	18	20·5		W			Slight	Extends over 3° from 19° to 22°.
February	1	9	34		5	E		1		At top.
		9	28		44·5	E	1			At base.
		10	1	12		W	1			At top.
	2	9	10	37		E	0·5			At base.
		9	20		9	E		0·5		Do.
		9	22		16	E	1			Do.
		9	27		8·2	W	1			At top.
	3	10	45		5·5	W	0·5			At top; extends over 3° from 4° to 7°.
	4	8	57		65	E		1		At top.
	5	10	30		36·5	E	1			Do.
		9	46	12		W	Slight			Do.
		9	47	28		W	1			Do.
	8	9	4	18		E		1		Do.
		9	10	15		E	3			Do.
		9	6		4	E	0·5			At base.
		9	8		14	E	1			Do.
	10	11	18		15	E		1·5		At top.
	11	9	0		13	W	0·5	1		To red at base; to violet at top.
	13	11	15		11	W	0·5			At top; extends over 4° from 9° to 13°.
	14	9	23	19·5		E	1			At top; extends over 3° from 18° to 21°.
		9	6		9·5	W			0·5	
		9	3	16·5		W	0·5			At top.
	15	10	0	30·5		E	1			At base.
		10	13		17	W	2			
	16	9	5		18	W		1		At base
		8	48	15		W		1		
	17	8	44		2	E		2		At top.
	18	8	36		5	W		2		At base.
	19	9	23	19		E	1			Do.
	20	9	0		11	W	1·5	0·5		Do.
		8	48	4		W		2		At top.
		8	48	6		W		Slight		Do.
		8	47	16·5		W		1·5		
		8	40	54·5		W	1			At top.
	21	9	38		23	E	Slight			Do.
		9	13	61		W	0·5			Do.
		9	12	77		W		Slight		At base.
	22	11	53	32·5		W		Do.		At top.
	23	9	15		79·5	E		1		Do.
		9	51		23	W		Slight		No prominence.
	25	8	50	40		W		1·5		At base.
	26	8	46		33·5	W		0·5		Do.
	27	9	22	45·5		E		0·5		At top.
	28	9	37		42·5	E		0·5		Do.
		9	4	37·5		W	Slight			At base.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1930.		H.	M.	°	°		A.	A.	A.	
March	1	9	32		29	E		1		At top.
	3	9	1	10		E	1			At base.
		8	58		23	W	0·5			At top.
	8	10	4		10	W	0·5	1		To red at top.
	9	10	1	2		E	1			At base.
		9	54	6		W	1	0·5		To red at top ; to violet at base.
	13	9	19		7	W		1		At base.
		9	11	14		W		1·5		At top; extends over 4° from 12° to 16°.
	14	9	33	26		E		1		At top.
		9	36		31·5	E	1			Do.
		9	24		20	W		2·5		At base.
	15	10	33	70		E		1		Do.
	16	8	37	82·5		E	2			At top.
	17	9	6	25		E	0·5			Do.
		8	50	71·5		W	Slight			At base.
	19	9	49		9	W		1		No prominence.
	21	10	55	25		W	0·5			
	22	9	24	19		E		1		At top.
	23	9	32	11		E		1		Do.
	28	9	21	18		W		1·5		Do.
	29	10	16		14	W		Slight		Do.
April	1	12	22	14		E	1			At top.
	2	9	21	25		E		0·5		Do.
	4	9	6		31	E		1		Do.
	5	10	33	11		E			1	Do.
		10	33	9		E		1		Do.
		10	26		74·5	E	1			No prominence.
	7	8	58		6	W		1		At base.
	9	10	15		4·5	W	2			On prominence; extends from 3° to 6°.
	10	10	15		77·5	W		1		At top.
	11	8	49		16	W	0·5			Do.
	12	9	32		30	W		1·5		At base.
		8	32	49·5		E		0·5		Do.
		8	14	12		W	1			At top.
	15	10	12		30	E		0·5		At base.
	17	8	50	82·5		E	1			At top.
	18	8	48	13		W	0·5			Do.
	20	9	20		29·5	E	1			At top ; extends over 9° from 25° to 34°.
		9	5		10	W	1·5	1		To violet at base.
		9	0	9		W		2		At top.
	24	9	28		24·5	E	1·5			At top ; extends over 3° from 23° to 26°.
		9	28		29·5	E	1			At top ; extends over 3° from 28° to 31°.
		9	8	26		W	Slight			At top.
		9	5	43·5		W		0·5		Do.
	25	9	36		26	W		1·5		Do.
	26	9	13		7	W	2			Do.
		9	19		5	W			1	At base.
May	1	9	35		14	E	1			At top.
	2	9	35	40·5		E			Slight	
		9	10	29		W		1		At top.
	4	9	8		35	W		1		At base.
	5	8	46		40	W	1			At top.
	11	10	59		14	W	0·5			Do.
	12	8	58	26		W	0·5			Do.
	16	9	25		11	E			1·5	
	17	8	46	51		W			Slight	
	18	8	43	9		E		0·5		At base.
	20	8	49	47		E		0·5		Do.
		8	52		2	W		1		
	22	9	44	77·5		E	0·5			At top.
		10	25	15		E			0·5	
		10	45		31	E		1·5		At top.

Date		Hour IST		Latitude		Limb	Displacement			Remarks
				North	South		Red	Violet	Both ways	
1930		H	M		°		A	A	A	
May	22	9	55	32		W	1	1 5		To red at top to violet at base
	25	8	50	11		E	0 5			At base
	29	9	48		11	W	Slight			At top
		9	16	26		W	0 5			Do
	30	9	24	8		W	1 5			Do
		9	7	45		W		1		Do
	31	9	12		69	E		1		Do
June	2	10	0	12		W	1 5			At top
		10	0	16		W	0 5			At base
	5	9	12	11 5		W	2 5			
	6	8	55	15		W		Slight		At base
	12	9	5	14 5		W	Slight			
	17	9	15		26	E	0 5			At base
		9	19		31	W		0 5		Do
	24	11	42	12		W	1 5			At top
		11	40	24 5		W		1 5		At base, extends over 3° from 23° to 26

The total number of displacements was 197 as against 250 in the previous half-year and their distribution was as follows —

Latitude		North	South
1°—30°		88	58
31°—60°		20	14
61°—90°		11	6
	Total	119	78
East limb			95
West limb			102
	Total		197

Reversals and displacements on the sun's disc

Three hundred and sixteen bright reversals of the $H\alpha$ line, 306 dark reversals of D_3 line and 30 displacements of the $H\alpha$ line were observed during the half year Their distribution is given below —

	North	South	East	West
Bright reversals of $H\alpha$	196	120	168	148
Dark reversals of D_3	192	114	161	145
Displacements of $H\alpha$	19	11	15	15

Twenty one displacements were towards the red, 4 towards the violet and 5 both ways simultaneously

Prominences projected on the disc as absorption markings

Photographs of the sun's disc in $H\alpha$ light were available from Kodaikanal and the co-operating observatories for a total of 177 days, which were counted as 174½ effective days The mean daily areas of $H\alpha$ absorption markings (corrected for foreshortening) in millionths of the sun's visible hemisphere and their mean daily numbers are given below —

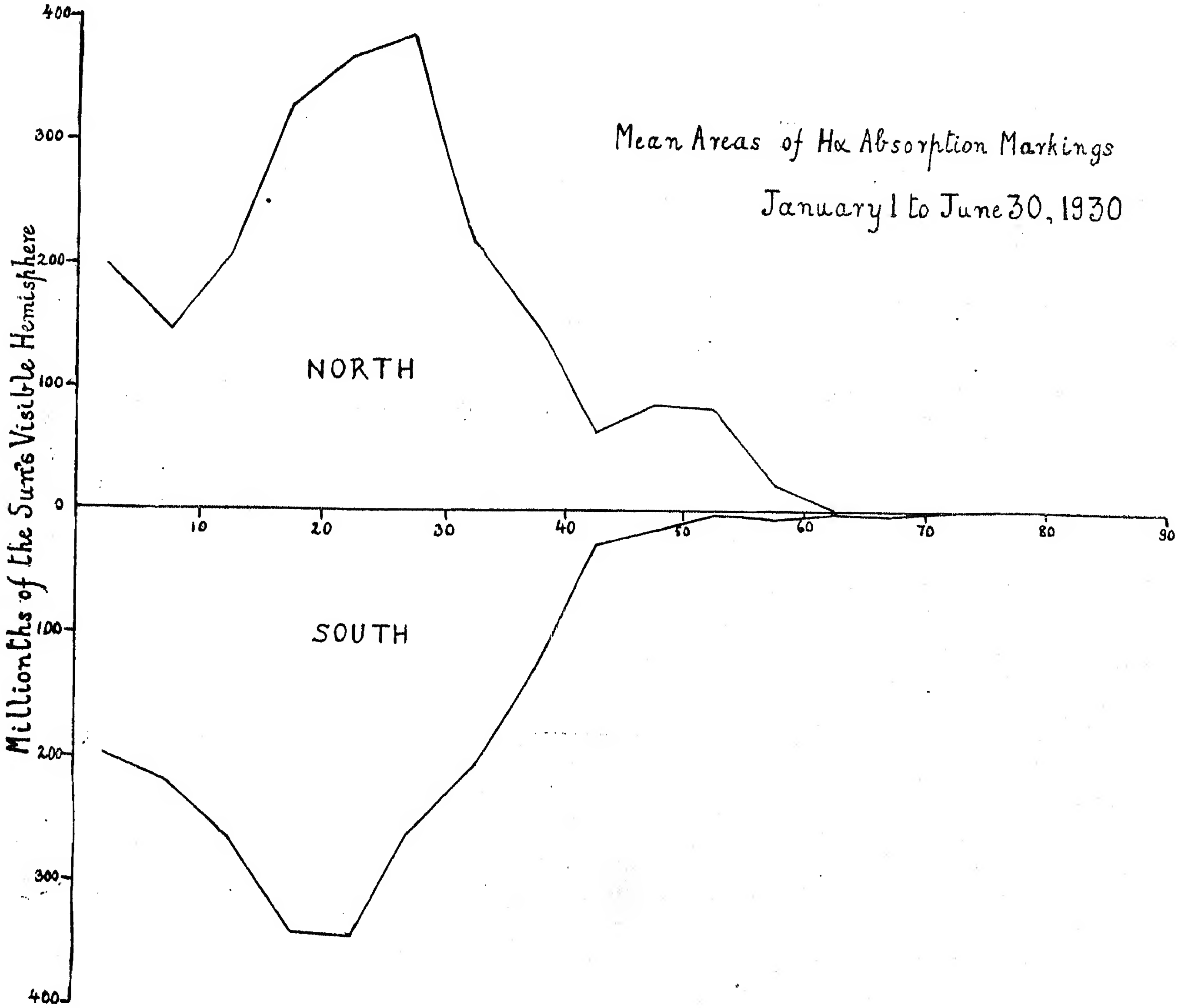
		Mean daily areas	Mean daily numbers
North		2,266	14 23
South		2,031	10 07
	Total	4,297	24 30

The above show an increase of about 2·2 per cent in areas and a decrease of about 4·8 per cent in numbers compared with the previous half-year. The preponderance of activity has now shifted back again to the northern hemisphere.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 156 days of observation being reckoned as $149\frac{3}{4}$ effective days.

	Mean daily areas.	Mean daily numbers.
North (Kodaikanal photographs only)	2,180	14·06
South (do.)	1,963	9·96
Total ...	4,143	24·02

The distribution of the mean daily areas in latitude is shown in the following diagram. The distribution is similar to that of the previous half-year except that the secondary maximum near 50° has disappeared in the southern hemisphere.



The areas as well as numbers are almost equally divided between the eastern and western hemispheres, the percentage east being 50·1 for both.

When the data for the areas of absorption markings were begun in Kodaikanal Observatory Bulletin No. XXIX it was considered that the projected areas should be corrected for the curvature of the sun's surface by multiplying by the secant of the angular distance of the marking from the centre of the sun's disc. This practice has been continued up to the present although it has been known for a long time that the projected areas do not actually vary according to such a law. The correction hitherto applied must therefore, sooner or later, be dropped. Since the law of variation of the projected areas has not yet been established it seems preferable to give the projected areas themselves without applying any correction. Until the effect of this change becomes clear the areas corrected as hitherto will continue to be given in future bulletins along with the uncorrected areas. Below are given the uncorrected projected areas for the first and second halves of 1929 and the first half of 1930.

	Mean daily areas (uncorrected for foreshortening).		
	Jan.—June. 1929.	July—Dec. 1929.	Jan.—June. 1930.
North	1,319	1,069	1,307
South	1,288	1,408	1,191
Total ...	2,607	2,477	2,498

Compared with the corrected areas the uncorrected areas amount to 58·3 per cent, 58·9 per cent and 58·1 per cent respectively of the corrected areas for these half-years. The curves of distribution in latitude are not much affected but it is not expected that this will hold when there is high latitude activity.

Thanks are due to the co-operating observatories for the photographs supplied by them.

KODAIKANAL,
24th February 1931.

T. ROYDS,
Director, Kodaikanal and Madras Observatories.

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Kodaikanal Observatory.

BULLETIN No. XCI.

ON THE SPARK SPECTRA OF LEAD

BY

A. S. RAO, M.A. (HONS.)

The spectrum of Lead has been the object of many investigations. Yet until recently little progress has b een made in the identification of series relationships in the arc and spark spectra of the element. This element is the chemical analogue of C, Si, Ge and Sn ; and since it has the same number and type of outer electrons its spectral structures may be expected, according to present-day theories, to resemble those of the abovementioned elements. Such resemblances between homologous spectra are often very close, though there are occasionally minor but significant differences, which may perhaps prove of importance in the refinement of modern atomic theories. Recently through the work of Thorsen[1], Grotrian[2], Sur[3] and McLennan[4], a distinct advance was made in the analysis of the arc spectrum of Lead. The first spark spectrum of the element was investigated by Geissler.[5]

The preliminary attempts at the classifications of the second and third spark spectra of Lead, from the existing lists of published wavelengths was seriously handicapped by the lack of descriptive data. Descriptions of arc and spark spectra of the element in limited wavelength intervals have been published by various observers. The most reliable ones up to the year 1911 are quoted by Kayser in Volume VI of the Handbuch der Spectroscopie. They are by Kayser and Runge[6] (arc spectrum 2085 to 6002-A.U.), by Thalen[7] (spark spectrum 4058 to 6656 A.U.), by Exner and Haschek[8] (arc spectrum 2237 to 6002 A.U., and spark spectrum 2170 to 4572 A.U.), and by Eder and Valenta[9] (arc spectrum 5609 to 7229 A.U., and spark spectrum 4272 to 6793 and 2088 to 2733 A.U.). Since the appearance of this work in 1912 the spectrum of this element has been reinvestigated by Klein[10], with greater accuracy by using a 20 feet concave Grating Spectro graph. All the abovementioned measures were based on Rowland's system of standard wavelengths. In addition to these, contributions to the spectra of Lead have been made by Kimura and Nikumura[11], who, by photographing the cathode spectrum grouped some of the important lines under successive stages. No attempts were made by these authors to measure the wavelengths accurately. Only after the present work was begun was the writer able to procure a paper published by S. Smith[12], who photographed by means of a two-metre concave grating, the vacuum spark between electrodes of the metal, in the region 2400 A to 4800 A. It is found however that the hot spark does not give the highest members of spark lines, which I have been able to photograph with the highest excitation in the condensed spark. This is clearly seen from an examination of the writer's spectrograms (plates II and IV).

The measurements till now available are not sufficient for a complete analysis of the spark spectrum of Lead, since it is desirable to know the degrees of excitation at which the various lines appear and also to know the character of the spectrum lines, i.e., their sharpness, diffuseness, etc. The experiments of the writer were therefore aimed at photographing the whole region 2050 to 7000 A, with higher dispersion and

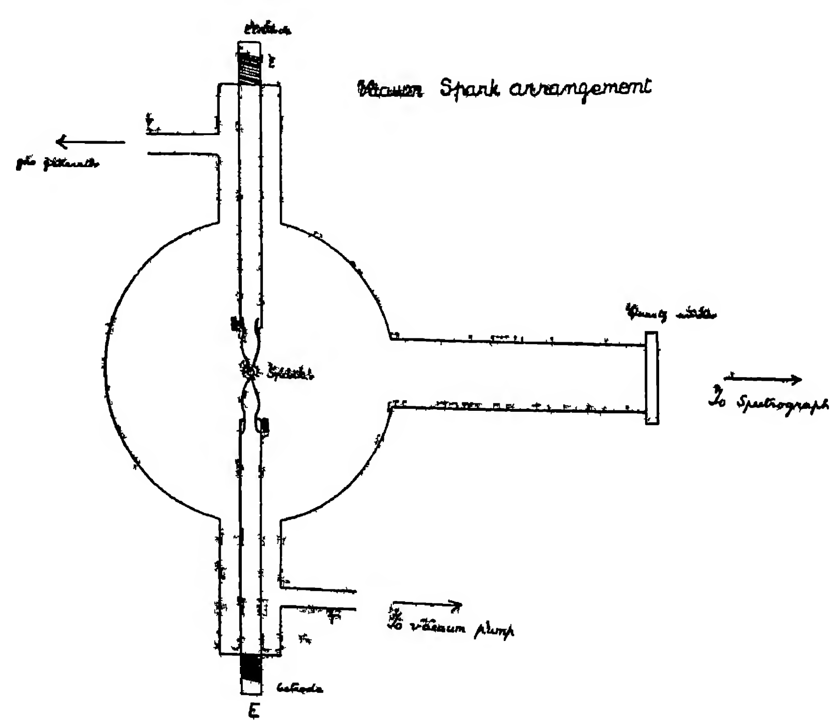
under different degrees of excitation as a preliminary to the analysis of the higher spark spectra The results show that the procedure is justified many additional lines having been discovered in this work The new observations of the spark spectrum together with the lines which have been classified in the spectra of Pb III and Pb IV are presented in this paper In addition to the accurate measurement of wavelengths attempts have been made in this investigation to improve upon the earlier descriptions by making a careful selection of the lines characterising Pb I Pb II Pb III and Pb IV This critical differentiation of lines belonging to different stages is generally made by photographing the spectrum under varying degrees of discharge

To provide data likely to be useful in identifying the spectra of higher stages of ionisation a study was made of the spark spectrum of pure Lead in air in vacuo and in an atmosphere of hydrogen at varying pressures and also of the arc in vacuum between electrodes of the pure metal The spark was produced by a ½ kilo watt 20000 volt transformer The secondary contained a battery of large plate condensers of capacity 0 03 m f d (constructed for the purpose) in parallel with the spark gap in the experimental chamber To distinguish lines due to different stages of ionisation the spectrum was photographed under varying degrees of discharge which is done by including in the secondary circuit a variable self inductance and capacity

Description of apparatus

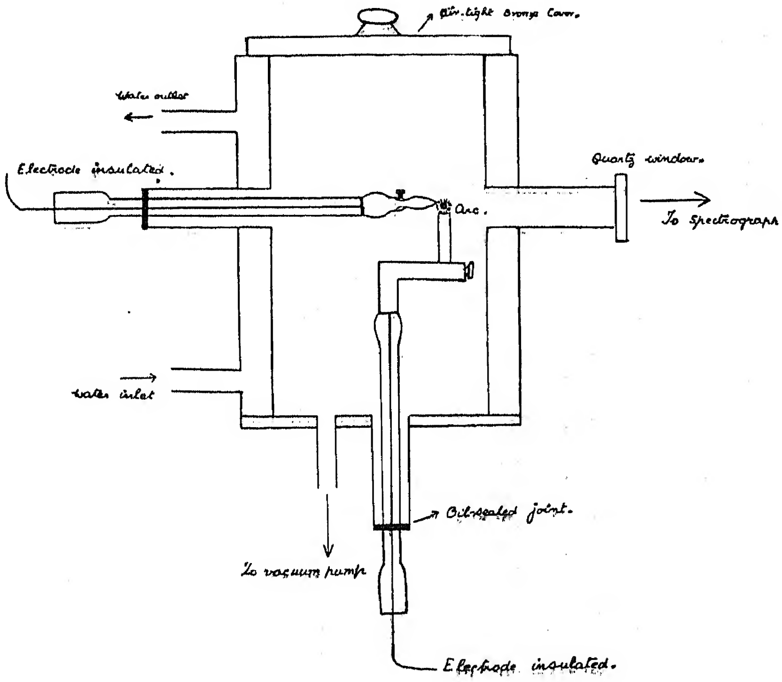
Sources of radiation —The apparatus used for the study of the spark spectrum is shown in diagram I It consists of a pyrex bulb capacity about one litre with side openings EI through which the electrodes pass To the ends of these small pieces of metal can be fixed A plane plate of quartz is attached to the end of the long projecting tube and serves as a window through which the spectrum of the spark is photographed. The two side tubulures (TT) are intended for filling the flask with hydrogen Pure hydrogen gas from a generator after passing through drying agents is passed through the flask for nearly 30 minutes, thereby driving the last traces of air from the flask By connecting the flask then to an air pump the flask could be exhausted to any desired pressure and the spark spectrum photographed

FIG 1



The spectrum of the vacuum arc of the metal was photographed, using a specially constructed arc lamp as the source of radiation. A diagrammatic sketch of the vacuum arc is given to Figure II. It consists of a double-walled cylindrical vessel fitted with a vacuum joint for one electrode and an aperture opposite for light to emerge. The second electrode passes through a similar joint in the base of the lamp and the clip for the specimen is arranged so that the arc is struck as close as possible to the window, without arcing to the wall taking place. The lid of the vacuum chamber is a bronze disc, which has been ground to make a tight joint which can be sealed with suitable vacuum wax or grease. Connection to the vacuum pump is made through the base of the lamp and nozzles are provided so that the cylindrical wall may be kept cool with circulating water. Each electrode consists of a brass tube passing through a gland and having an insulated wire passing through it. Electrical connection is made to the terminal situated on the ebonite handle, provided for the manipulation of the arc. The glands have been filled with vacuum grease for maintaining a vacuum. The lamp operates steadily with currents varying from 4 to 6 amps.

FIG. II.



Spectrographs employed.—The spectrograms were obtained in the first and second order of a 4-inch concave grating, of 10 feet radius of curvature in eagle mounting. These were supplemented by several plates taken with a Hilger E_2 Quartz spectrograph, which is used not only to record the faint lines in the ultra-violet, but also for wavelength measurements in the region 2550 to 2050-A. In this region this spectrograph compares favourably in dispersion and resolving power with the concave grating spectrograph and at the same time, has a good light gathering power. Comparison spectra of the iron arc are impressed on the plates after each of the exposures. The spectrograms are obtained on photographic plates of thin glass which could be bent to the focal curves of the spectrographs. The region 3600 to 6500-A was also visually examined, with a view to study the behaviour of the lines under different conditions of excitation, by a constant deviation spectrograph. For photographing the region below 2500-A, the plates were sensitized in the manner described in Volume II of Baly's Spectroscopy, with comptometer oil. The exposure times ranged, in the case of the concave grating spectrograph from 10 to 30 minutes, while in the case of the quartz spectrograph, up to 2500-A, the times ranged from 5 to 10 minutes and in the region 2500 to 2050-A exposures of 15 to 30 minutes were given.

Method of wavelength determınatıon —All plates were measured ın two dırectıons wıth a Hılger comparator and the wave length measurements were made relatıve to Internatıonal Secondary Standards ın the spectrum of the ıron arc For the regıon below 3370 A the ıron arc wavelengths publıshed by Burns were used In the case of the prısm spectrograms the wavelengths were calculated by means of Hartman s dıspersıon formula $\lambda=\lambda_0 + \frac{c}{n}$ where λ_0 c and n are constants determıned from the comparıson spectrum and n the dıstance of the unknown lıne from a fixed poınt of reference on the plate Spectrograms obtaıned wıth the gratıng are measured by usıng a lınear scale

Intensıty estımates were made dırectly from the plates as vıewed ın the measurıng mıcroscope on a scale of 0 to 10 The vacuum wave numbers correspondıng to the observed wavelengths are taken from Kayser s Tabelle der Schwıngungszahlen and are gıven ın column 3 of Table I In column 1 are gıven the observed wavelengths ın I A In column 2 are gıven the ıntensıty estımates ın column 4 the stages of ıonısatıon of the promınent lınes and ın column 5 are gıven the lınes classified ın thıs ınvestıgatıon The symbols accompanyıng the ıntensıty values have the followıng meanıngs –

s = sharp d = dıffuse bd = broad and dıffuse and dd = very dıffuse

TABLE I

Wavelength (I.A.)	Int	Wave number cm⁻¹	Stage and classification
655 82	3	152439	IV 6 D —7p P
760 90	0	131420	IV 6 D —7p P
804 55	1	124293	IV 6 D —7p P
884 98	6	112997	IV 6 D_3—7p P
908 54	5	110067	IV 1 P —2 S
922 5	4	108401	IV 1 P —1 D
979 47	2	102096	IV 6 D_3—7p D_2
995 8	2	100422	III 1 P —1 $^3\bar{P}$
1028 7	10	97210	IV 1 S —1 P
1030·5	3	97040	III 1 ^{3}P —1 D
1048 9	12	95338	III 1 S —1 P
1059 3	1	94400	IV 6 ^{2}D —7p ^{4}P
1069 2	2	93528	III 1 P —1 D
1074 7	3	93049	III 1 P —1 D
1087 34	2	91968	IV 6 D_2— 7p^1 P
1096 5	1d	91189	IV 6 D —7p D
1103 6	0d	90613	IV 6 D —6p D
1104 8	0d	90510	IV 6 D_3—6p F
1115 0	2	89686	III 1 ^{3}P —1 S
1116 2	4	89590	IV 1 ^{3}P —1 D
1118 6	3	89397	III 1 P —1 D
1123 45	3	89012	IV 1 P_2—2 S
1142·9	1	87497	III 1 P —1 $\bar{P}$
1145 0	3	87336	IV 1 P —1 D
1165 1	4	85830	III 1 P —1 $\bar{P}$
1167 0	4	85690	III 1 P —1 S
1231 3	1	81215	III 1 ^{3}P 1 $\bar{P}$
1233·6	3	81068	IV 6 D_2—7p D
1250·6	4	79962	III 1 P_2—1 D
1266·9	1	78933	III 1 P_2—1 ^{3}D
1274·6	0	78456	III 1 $^3P_2$- 1 ^{3}D
1279·5	3	78167	IV 6 D —6p F
1308 2	2	76441	IV 6s^1 D —6p^1 D
1313 2	9	76150	IV 1 ^{2}S —2 P
[illegible]	0	73381	IV 6s^1 $^2D_2$—7p^1 P
1371 8	3	72897	III 1 P_2—1 P
1406 6	2	71093	III 1^{3}P – 1 S
1437·1	1d	69585	IV 6s^1 D_2—6p D
1439 2	1d	69478	IV 6 D_2—6p F_2
1553 1	20	64387	III 1 S —1 P
1597 8	0	62586	III 1 P —1 D_2
1610 1	1	62107	III 1 P —1 D
1711 1	4	58442	III 1 P —1 D_2
1749 9	1	57146	IV 6 D_2—6p F
1826 2	0	54759	III 1 P —1 S
Th wrnt me s b gı her			
2060 43	3	48518 0	
2088 55	2	47864 8	I
2104 41	2dd	47504 1	
2107 73	5dd	47429 3	
2110 75	3	47361 5	
2114 98	1dd	47266 8	I
2132 21	3s	46884 8	
2142 83	5s	46652 5	
2152 64	4	46439 9	
2169 86	10bd	46071 4	
2174 61	0dd	45970 8	
2178 72	1s	45884 1	
2189 76	6	45652 8	I
2192 43	2	45597 2	
2203 62	8dd	45365 7	II
2218 21	3	45067 3	I
2237 48	8b	44679 2	I
2242 67	5	44575 8	
2246 83	10bd	44493 3	I
2254 13	3dd	44349 2	I
2259 76	0dd	44238 8	
2264 73	1s	44141 7	
2276 58	3s	43911 9	
2280 51	1s	43886 3	
2287 52	1bd	43702 0	
2290 17	0dd	43651 4	
2293·02	1bd	43597 1	
2294 16	0	43575 5	
2296 65	2	43528 2	
2300 35	4s	43458 2	IV 2 P —3^{2}S

TABLE I—*cont.*

Wavelength (I.A.)	Int.	Wave number in cm.$^{-1}$	Stage and classification.
2308 12	0bd	43312·7	
2312·70	0d	43226·2	
2317·45	2dd	43137·6	
2332·48	8bd	42859·7	I.
2343·72	1s	42654·1	
2353·91	0d	42469·5	
2360·19	1dd	42356·5	
2368·54	2d	42207·2	
2370·27	0s	42176·4	
2382·28	3s	41963·8	
2386·01	2s	41898·2	
2389·12	4s	41843·6	I.
2393·88	7dd	41760·5	
2399·76	3s	41658·1	
2402·16	7bd	41649·3	I.
2411·79	6bd	41450·4	I.
2416·13	0	41375·9	
2418·78	0	41330·6	
2424·21	0	41238·0	
2428 70	8bd	41161·8	IV $2^2P_1-2^2D_2$.
2433 65	2s	41078·1	
2443·91	10bd	40905·6	
2446·30	10bd	40865·7	I.
2463·21	2	40585·2	
2476·38	9	40369·3	
2478·63	3	40332·7	
2494·07	2d	40083·0	
2495·61	3d	40058·3	
2497·16	2s	40033·4	
2508·87	2	39846·6	
2527 06	3dd	39559·8	II.
2533·38	3dd	49461·1	IV.
2534·81	3dd	39438·8	IV.
2562·37	10	39014·7	III.
2568·48	6	38921·9	IV.
2577·34	8	38788·1	II.
2613·78	10	38247·4	
2614·28	5	38240·0	I.
2628·37	6	38035·1	I.
2637·81	3	37899·0	
2638·53	3	37888·6	II.
2640·51	3s	37860·2	
2650·33	6dd	37719·9	
2957·15	4s	37623·1	I.
2663·23	10	37537·2	I.
2697·60	5d	37059·0	
2712·81	0	36851·2	
2717·38	6d	36789·3	II.
2719·97	3d	36754·2	II.
2733·23	2	36575·9	I.
2734·58	2	36557·9	I.
2737·00	2	36525·6	I.
2740·87	2	36474·0	
2745·51	4	36412·4	
2752·15	1	36324·5	IV $2^2P_2—3^2S_1$.
2755·81	0	36276·3	
2802·00	10	35678·3	I.
2823·25	10	35409·8	I.
2833·12	10	35286·4	
2864·45	10	34900·5	IV $2^2P_2—2^2D_3$.
2868·19	3	34855·0	
2873·33	10	34792·6	I.
2937·55	4	34032·0	IV $2^2P_2—2^2D_2$.
2949·45	9dd	33894·7	II.
2977·98	9	33570·0	I.
3002·65	5s	33294·2	II.
3010·19	3s	33210·8	
3016·63	8dd	33139·0	II.
3025·55	2d	33042·3	
3028·77	2	33007·1	
3031·68	4s	32975·5	IV.
3043·90	10	32843·1	III $1^3D_1—1^3F_2$.
3052·64	10	32749·0	IV.
3056·84	4	32704·0	IV $1^2D_2—{}^2P_2$.
3062·42	4	32644·5	
3071·54	4	32547·5	
3087·13	5	32383·2	IV.
3089·17	7	32361·8	III $1^2D_2—1^3F_2$.
3103·00	4	32217·6	III.
3109·27	2	32152·6	
3118·17	5	32060·8	I.
3129·62	4	31943·5	III.
3137·87	10	31859·5	III $1^3D_2—1^3F_3$.
3145·70	4	31780·3	III.
3176·59	10	31471·2	III $1^3D_3—1^3F_4$.
3191·49	1	31324·3	III $1^3D_3—1^3F_2$.
3214·82	0	31097·0	
3221·00	10	31037·3	IV $2^2S_1—2^2P_2$.
3227·16	3	30978·1	IV.
3231·31	3	30938·3	
3240·21	9	30853·3	I.
3242·95	9	30827·3	III $2^2D_3-2^3F_3$.
3247·70	2	30782·2	
3262·41	3	30643·4	I.
3276·15	9	30514·9	III $2^3P_1—2^3D_2$.
3279·30	9	30485·6	III.
3280·09	9	30478·2	IV $1^3D_3—2^3P$.
3298·04	9	30313·3	III $2^3P_1—2^3D_1$.
3309·22	8d	30209·9	
3360·40	4s	29749·8	
3361·59	4s	29739·3	
3365·93	5s	29701·0	
3437·15	2s	29085·6	III.
3452·17	6d	28950·0	II.
3455·18	8d	28933·8	III.
3476·27	0	28758·3	
3483·46	9	28698·9	III $1^3F_3—1^3G_4$.
3505 37	3d	28519·5	III $1^3F_4—1^3G_5$.
3530·39	3	28317·4	
3534·06	3d	28288·0	
3560·75	6	28076·0	III $1^1D_2—1^1F_3$.
3563·06	4	28057·8	III $1^3F_4—1^3G_4$.
3565·26	1	28040·5	
3567·16	3	28025·5	III $1^1D_2-\beta$.
3572·79	10s	27981·4	
3586·29	5d	27876·0	
3589·81	7d	27848·7	III $1^3F_3—1^3G$.
3592·95	6s	27824·4	IV $2^2D_3—2^2F_3$.
3621·10	1s	27608·1	
3639·66	10s	27467·3	I.

TABLE I—*cont*

Wavelength (I A)	Int	Wave number in cm⁻¹	Stage and classification
3648 61	1bd	27400 1	
3655 56	8d	27347 8	III $1^3F_2—1^3G_3$
3665 64	0	27272 6	III
3671 48	10d	27229 3	I
3674·75	4	27205 0	III $1^3F_4—1^3G_3$
3683 57	10s	27139 9	
3689·22	8s	27098 2	III $1^3S_1—2^1P_1$
3699 52	0bd	27022 9	
3706 22	3d	26974 0	III $2^3P_0—2\,^3S_1$
3714 10	5dd	26916 8	II
3719 30	2dd	26879 2	
3729 06	4	26808 8	III $2^3P_1—2^3S_1$
3735 98	7	26759 2	
3740 13	10s	26729 5	
3749 22	1	26664 7	
3786 20	8d	26404 2	II
3827 66	8d	26118 2	III $2^1P_1—2\,^3D_2$
3832 94	10s	26082 3	III $2^3P_1—\alpha$
3841 83	10d	26021 9	III $2^3P_2—2^3D_3$
3854 11	10s	25939 0	III $1^3S_1—2^3P_2$
3873 22	1s	25811 0	IV
3909 29	5d	25572·9	IV $1^2D_2—2^2P_1$
3927 74	3b	25452 8	
3943 79	1ss	25349 2	
3952·11	8d	25295 8	III $1^3\bar{P}_0—2^3P_0$
3962·58	8s	25229 3	
3994 98	1s	25024 1	
4004 35	3s	24965 8	
4019 65	8s	24870 8	I
4031 48	3d	24797 8	
4041 51	1	24736 3	
4049 88	7s	24685 1	
4058 01	10dd	24635 8	I
4062 22	8s	24610·2	I
4077 51	2db	24517·9	
4095 04	2d	24412·9	
4128 34	2d	24216·0	III
4141 56	3b	24138 7	III $1^3\bar{P}_1—2^3P_2$
4153 99	3db	24066 5	
4168 05	7s	23985·3	I
4174 38	4s	23948 9	III $1^3D_2—1^3F_3$
4182 40	8s	23903·0	IV $2^2S_1—2^2P_1$
4242 50	3dd	23564 4	II
4245 47	10	23547·6	II
4272 64	8s	23398 2	III $1^1D_2—2^1P_1$
4386 89	10	22788·8	II
4400·95	6s	22716 0	III
4447 10	3d	22480·3	
4496 12	3s	22235·2	III $1^1D_2—2^3P_2$
4499 73	2	22217·3	
4534 54	3d	22046 8	
4571 45	7s	21868 8	III $2^3P_2—2^3S_1$
4605 28	3sd	21708 1	
4630 38	5s	21585 8	
4761 00	8s	20998 1	III $1^3S_1—2^3P_1$
4798 27	6s	20835 6	III $1^3S_1—2^3P_0$
4802 18	6s	20818 1	
4827 15	0	20710 4	III $2^1P_1—2^3S_1$
4855 20	1	20590 7	
4885 71	1	20462 2	
4941 12	1d	20232 7	
5003 59	3s	19980 1	III $2^1P_1—\alpha$
5005 68	6s	19971 8	
5043 21	10	19823 1	II
5062 91	3s	19746 0	III $1^3D_2—2^1P_1$
5066 24	3s	19733 0	
5117 31	2sd	19536 1	
5139 42	2s	19452 0	
5163 75	6s	19360 4	IV
5192 29	6s	19253 0	III $1^3D_1—2^1P_1$
5201 65	6s	19219 3	
5207 17	6d	19199 0	III $1^3\bar{P}_1—2^3P_1$
5220 42	2dd	19150 2	
5252 33	8d	19033 9	III $1^3\bar{P}_1—2^3P_0$
5274 51	4s	18953 8	IV
5372 65	10	18607 6	II
5471 80	1	18270 5	II
5496 61	1s	18188 0	
5523 50	5s	18099 4	III $1^3D_2—2^3P_2$
5544 60	1	18030 6	
5545 11	10	18028 9	II
5609 18	10	17823 0	II
5664 49	3s	17649 0	
5677 53	3s	17608 4	
5678 89	3s	17604 2	
5707 67	2s	17515 4	
5779 75	4s	17297 0	III $1^1D_2—2^3P_1$
5828 12	3sd	17153 4	
5857 59	6s	17067 1	III $1^3D_3—2^3P_2$
5876 65	7d	17011 8	II
5890 33	6s	16972 3	
5893 01	6s	16964 6	
5930 31	2s	16857·9	
5941 05	2s	16827 4	
6002 13	5s	16656 1	
6039 12	5s	16554 1	
6081 81	3dd	16437 9	II
6379 98	1	15669 7	
6660 15	8s	15010 5	II
6792 94	3s	14717 1	II

In addition to the spectrograms and wavelength measures obtained by the author, the wavelengths of Carrol and Mack have been used for the region 2100 A

Spectrum of Pb III

From the position of Pb in the table of elements it must be expected that the second spark spectrum consists of singlets and triplets and that the structure resembles generally that of the chemically analogous atom or ion C III, Si III, Ge III, and Sn III, Al II Ga II, In II and Tl II All these, except Pb III and

Pb IV, have already been analysed. The present work on Pb III, Pb IV, therefore completes our knowledge of the series regularities in the spark spectra of elements of the fourth group. According to the theory of spectra developed by Pauli-Heisenberg, Russel and Hund, the characteristic terms arising out of any electronic configuration can be predicted with certainty and it will be seen that the results of the analysis of these spark spectra are in complete agreement with the theoretical predictions. The structure diagram of doubly ionised Lead may be written in the following manner :—

TABLE II.

K														
2														
	L_1	L_2												
	2	6												
		M_1	M_2	M_3										
		2	6	10										
			N_1	N_2	N_3	N_4								
			2	6	10	14								
				O_1	O_2	O_3	O_4	...						
				2	6	10								
					P_1	P_2	P_3	...						
					2									
						Q_1	Q_2	...						

There are two electrons outside the complete spectroscopically neutral shells, which alone are effective in producing the optical spectrum. The most stable structure is that in which the two valency electrons are in the P_1 level. The spectroscopic term corresponding to this configuration is $^1S_0$. Other less stable configurations and their characteristic terms are obtained by keeping one of the electrons in the P_1 orbit and allowing the other to run through the orbits P_2, Q_1, O_4, etc. The terms that these different electron configuration give rise to, may be predicted by the Hund Theory and are shown in the following table :—

TABLE III.

Electron configuration.		Terms predicted.	Terms observed.
2	P_1	1^1S_0	1^1S
$1P_1$	$1P_2$	1^3P, 1^1P	1^3P, 1^1P
$1P_1$	$1Q_1$	1^3S_1, 2^1S_0	1^3S, 2^1S
$1P_1$	$1O_4$	a^3F, a^1F	...
$1P_1$	$1P_3$	1^3D, 1^1D	1^3D, 1^1D
$1P_1$	$1Q_2$	2^3P, 2^1P	2^3P, 2^1P
$1P_1$	$1R_1$	2^3S_1, 2^1S_0	2^3S, 2^1S
$1P_1$	$1O_4$	1^3F, 1^1F	1^3F, 1^1F
$1P_1$	$1O_5$	1^3G, 1^1G	1^3G
$1P_1$	$1Q_3$	$2^3\underline{D}$, 2^1D	$2^3\underline{D}$, 2^1D
2	P_2	$1^3\overline{P}$, 1^1D, ^1S	$1^3\overline{P}$

The first clue to the identification of the triplet systems in Pb. III was the detection of the fundamental group $1^3D—1^3F$, which should occur in the visible and quartz regions and which could be examined under different experimental conditions. Observations have also been made in the visible region with a prism spectroscope to find the intense triplet $1^3S_1—2\ ^3P_{012}$. The result is the identification of the prominent triplet given below :—

TABLE IV.

λ	Int.	ν	Δν
3854·05	12	25939·4	
			4941
4761·00	6	20998·1	
			163
4798·27	4	20835·0	

The choice of this is further supported by the detection of the member $1^3D_{23}—2^3P_2$ in the calculated region and by the identification of the triplet $2^3P—2^3S$ of the sharp secondary series The 2^3P separation (4941) is found to be in complete agreement with the value predicted from the relativistic doublet law

The first principal, sharp and diffuse series fall in the extreme ultraviolet which does not lend itself to careful examination of the lines Attempts were therefore made to fix by extrapolation and then to seek for confirmation by correlating the corresponding members of the spectra of corresponding elements A very valuable clue to the detection of these members is afforded by the application of the relativity laws to isoelectronic spectra of Hg-like atoms

An approximate idea of the 1^3P_{12} separation was obtained from the regular doublet sequence and from the relation that in the spectra of the same vertical group of the periodic table $\left(\frac{\Delta\nu}{Z^2}\right)$ is approximately constant These give for 1^3P_{12} a value of about 14000 and for 2^3P_{12}, a value between 4000 and 5000

The following table shows the regular doublet sequence for 1^3P_{12} and 2^3P_{12} separations and the value of $\left(\frac{\Delta\nu}{Z^2}\right)$ for elements of the same vertical group —

TABLE V —REGULAR DOUBLET SEQUENCE

	1^3P_{12} separation	$\sqrt[4]{\Delta\nu}$	2^3P_{12} separation	$\sqrt[4]{\Delta\nu}$
Hg I	4630 6	8 25	1545 6	6 27
Tl II	9339	9 83	2839	7 30
Pb III	14595	10 99	(4941)	8 40

TABLE VI —VARIATION OF $\Delta\nu/Z^2$

At No Z	Element	2^3P_{12}	$\Delta\nu/Z^2$	1^3P_{12}	$\Delta\nu/Z^2$
6	C III	12 8	356		
14	Si III	73 16	373	263	1 342
32	Ge III	459	448	1642	1 603
50	Sn III	1222 8	491	4031	1 613
82	Pb III	(4941)	60	14595	2 171

The application of the irregular doublet law to Hg like atoms indicated that the probable position of $1^3P_2—1^3S_1$ is at ν 70000 nearly In applying this sequence the method of Millikan and Bowen is adopted as shown below In the usual notation, the irregular doublet law may be written as follows —

$$\frac{\nu^1}{R}=\frac{(n_2^2-n_1^2)\,z^2-z\,(n_2^2\sigma_1\ \ n_1^2\sigma_2)+(n_2^2\sigma^2-n_1^2\sigma_2^2)}{n_1^2n_2^2}$$

When a line results from transition between orbits of two different total quantum numbers, (n_2 & n_1) we get from the above equation, by transposition

$$\nu^1=\nu-\frac{R\,(Z-A)^2\,(n_2^2-n_1^2)}{n_1^2n_2^2}=C^1Z+D^1$$

The expression on the left varies therefore linearly with the atomic number Z, for any given set of values n_2 & n_1 In the case of $1^3P_2—1^3S_1$ of Hg like atoms $n_1=6$, $n_2=7$ and $A=79$ The progressive variation of ν^1, with atomic numbers is shown in the following table —

TABLE VII

At No. Z	Element	$\nu\ (1^3P_2-\nu\,^3S_1)$	$\nu^1=\nu-808\,3\ (Z\ A)^2$	Difference
80	Hg. I	20782	19974	
81	Tl II	43501	40268	20294
82	Pb III	(71093)	63818	22550

Attempts have also been made, by the application of the Mosley law to the spectra of Ge III & Sn III and to the spectra of Hg-like atoms, to fix the approximate position of this triplet as a check on the irregular

doublet sequence. A careful search was then made for the possible triplet 1 $^3P_{012}$—1 $^3S_1$ among Caroll's [13] measures, below 1450 A, having in view the relative order and magnitude of intensities and the probable ratio of intervals between the lines, with the result that the following triplet was fixed.

TABLE VIII.

λ	Int.	ν	Combination.	
1406·6	2	71093	1 $^3P_2$—1 $^3S_1$	14595
1167·0	4	85690	1 P_1—1 S_1	3994
1115·0	2	89686	1 P_0—1 S_1	

Evidence for the possibility of this being the triplet in question is sought by searching for the complete six-line multiplet (diffuse) 1 ^3P—1 ^3D.

The triplet 2 $^3P_2$—2 $^3S_1$ being fixed in the case of Pb III, attempts have been made by the application of the irregular doublet sequence to locate the corresponding triplet in the case of Tl II, which has not been identified. In this case $n_2 = 8$, $n_1 = 7$ and $A = 79$.

$$\frac{R\ (n_2^2 - n_1^2)}{n_1^2\ n_2^2} = 584{\cdot}61.$$

The sequence is—

Z	Element.	ν.	$\nu^1 = \nu - 524{\cdot}6\ (Z\text{-}A)^2$.
80	Hg. I	2753·6	2229·0
81	Tl. II	...	[9690]
82	Pb. III	21868·8	17146·9

The interpolated value of ν^1 for Tl II is $\nu^1 = 9690\ (\pm\ 500)$.

$\therefore \nu = 9690 + 2097\ (\pm\ 500) = 11787\ (\pm\ 500)$, which is in the infra red, at about 8500-A.

A very interesting feature noticed in the spark spectrum of Lead is the partial inversion of the triplet F term, 1 $^3F_{23}$ being negative. The location and identification of the complete six-line multiplet 1 ^3F—1 ^3G, in approximately the calculated position is a strong evidence as to the correctness of the identification of the ^3F terms.

The singlet system of lines is generally the most difficult to work out. When this analysis was first undertaken not much progress could be made at first in the identification of the singlet spectrum. The strong line 1048·9 (12) was suggested as 1 $^1S_0$—1 $^1P_1$ and 1553·1 (20) as 1 $^1S_0$—1 $^3P_1$. While this work was in progress, the author's attention was drawn to a similar publication by Smith [14]. Although there is good agreement between the results of Smith and those of the author, there is disagreement in one or two important points. Smith has the following as 1 ^3P—1 ^3S and 1 ^3P—1 $^3\bar{P}$.

TABLE IX.

	1 $^3P_2$.	1 $^3P_1$.	1 $^3P_0$.
$^3S_1$	76447 (15)	91047 (10)	95036 (7)
$^3P_0$	...	78157 (15)	
P_1	71095 (12)	85694 (15)	89687
$\bar{P}_2$	85833 (15)	100428 (10)	

It was pointed out in a note communicated to Nature [15] that evidently Smith had the author's 1 $^3S_1$ as his 1 $^3P_1$ and that 1 $^3S_1$ suggested by the writer was further supported by the location and identification of the second series 1 ^3S—2 ^3P, 1 ^3D—2 ^3P & 2 ^3P—2 ^3S. The 1 ^3P—1 ^3S suggested by the author followed the irregular doublet law for the isoelectronic spectra of Hg-like atoms more closely. The author therefore suggested that an interchange of the two levels 1 $^3S_1$ & 1 $^3\bar{P}_1$ of Smith would bring the whole scheme into alignment. Attempts have also been made by the writer to identify the singlet spectrum, the results of which

have been published in a paper Smith[14] has since published another paper on the second spark spectrum of lead, in which the suggested modification was adopted There are still however two main points of disagreement between the classification of the writer and that of Smith The term $\nu = 101434$, classified by the author as 6s 6d $^1D_2$ is classified by Smith as 6s 7s $^1S_0$ Smith classified 1768 67 (56540) as 1 $^1P_1 - 1^1D_2$, while the writer classified 1711 1 (58442) as this combination It will be seen from the irregular doublet sequence shown below (Table X), that both 1 $^1P_1 -$ 1 $^1D_2$ and 1 $^1D_2 - 2$ $^1P_1$ identified by the writer show a distinctly better progression than those of Smith Further the line 1 $^1P_1 - 1$ $^1D_2$ should be a strong line It is found that most of these strong lines of the triplet and singlet systems are found in the wavelength measures of McLennan, Young and Ireton, Bloch and Lang But the line 1768 67 identified by Smith as 1 $^1P - 1$ ^1D is not recorded by any of the previous investigators, while Carrol includes it as one of the lines belonging to Al These considerations indicate that the writer's classification and identification of 1 $^1D_2$ is more probable

TABLE X—IRREGULAR DOUBLET SEQUENCE

	1 $^1S_0 - 1$ $^3P_1$	1 $^1S_0 - 1$ $^1P_1$	1 $^1P_1 - 1$ $^1D_2$
Hg I	39413	54065	17265
Tl II	52390	75656	39501
Pb III	64387	95338	58442 — 56540

From the beginning of this investigation of the analysis of Pb III, it was felt that ^3P ^3P group should be strong as in the case of the chemically analogous atoms or ions 1 $^1D_2$ and 2 $^1D_2$ terms of Smith are probably 1 $^3\bar{P}_1$ and 2 $^3\bar{P}_1$ On this supposition ^3P $^3\bar{P}$ group and the resulting combinations have been identified by the author, thus supporting the validity of the writer's identification of 1 $^1D_2$ term The term values have been determined by assuming 1 $^3F_4 = 64\,800$, $\left(\frac{\nu}{9} = 7200\right)$ The resonance and ionisation potentials are 7 95 and 31 5 volts respectively, the largest term 1 $^1S_0 = 255216$ The details of the triplet and singlet systems identified in this investigation are given in the accompanying tables Table XV gives the configurations and term values for Tl II and Pb III and Table XVI gives other unclassified members of $^3P_{12}$ differences

TABLE XI

	1^3P_2 176234	(14595)	1^3P_1 190829	(3994)	1^3P_0 194823
1^3S_1 105141	1406 6 (2) 71093		1167 0 (4) 85690		1115 0 (2) 89686
1^3D_1	1274 6 (0) 78456		1074 7 (3) 93049		1030 5 (3) 97040
1^3D_2	1266 9 (1) 78933		1069 2 (4) 93528		
1^3D_3	1250 6 (4) 79962				
$1^3\bar{P}_0$ 109690			1231 3 (1) 81215		
$1^3\bar{P}_1$ 103332	1371 8 (3) 72897		1142 9 (1) 87497		(91491)
$1^3\bar{P}_2$ 90407	1165 1 (4) 85830		995 8 (2) 100422		

TABLE XII.

	2^3P_2 79202	4941	2^3P_1 84143	164	2^3P_0 84307
1^3S_1 105141	3854·11 25939 (10s)		4761·0 20998 (8s)		4798·27 20835 (6s)
2^3S_1 57334	4571·45 21868·8 (7s)		3729·06 26808·8 (4)		3706·22 26974 (3)
1^3D_3 96272	5857·59 (6) 17067·1 obs. 17070 cal.				
1^3D_2 97304	5523·5 (5) 18099·4 obs. 18102·0 cal.		Inf. red.		
1^3D_1 97785			Inf. red.		Inf. red.
$1^3\overline{P}_2$ 90407	Inf. red.		Inf. red.		
$1^3\overline{P}_1$ 103332	4141·56 24139 (3)		5207·17 19199 (6)		5252·33 19034 (3)
$1^3\overline{P}_0$ 109690			(25570)		3952·1 25296 (8)
2^3D_1 53827	3939·77 25375·0		3297·64 30316 (4)		3279·91 304799 (2)
2^3D_2 53628	3907·17 25573·7 (5)		3276·19 30514·5 (7)		
2^3D_3 53179	3841·6 26023·3 (7)				

TABLE XIII.

	1_3F_4 64800	(643)	1^3F_3 65443	(-502)	1^3F_2 64941
1^3D_3 96272	3176·59 31471·2 (10)		3242·95 30827·3 (9)		3191·49 31324·3 (1)
1^3D_2 97304			3137·87 31859 (10)		3089·17 32361·8 (7)
1^3D_1 97785					3043·9 32843·1 (10)
1^3G_5 36280	3505·37 28519·5 (3)				
1^3G_4 36742	3563·06 28057·8 (4)		3483·46 28698·9 (9)		
1^3G_3 37595	3674·75 27205 (4)		3589·81 27848·7 (7)		3655·56 27347·8 (8)

TABLE XIV.—SINGLET SYSTEMS.

Classification.	λ	Int.	ν Observed.	ν Calculated.
$1^1S_0-1^3P_1$	1553·1	20	64387	...
$1^1S_0-1^1P_1$	1048·9	12	95338	...
$1^1P_1-1^3S_1$	1826·2	0	54759	54737
$1^1P_1-1^3D_2$	1597·8	0	62586	62577
$1^1P_1-1^3D_1$	1610·1	1	62107	62103
$1^3S_1-2^1P_1$	3689·22	7	27098·2	...
$2^1P_1-2^3S_1$	4827·1	1	20710·4	20709
$2^1P_1-2^3D_2$	3827·66	8	26118·2	...
$1^3P_1-1^1D_2$	1118·6	3	89397	89393
$1^1P_1-1^1D_2$	1711·1	4	58442	...
$1^1D_2-2^1P_1$	4272·64	8	23398	23393
$1^1D_2-2^3P_2$	4496·12	3	22235	22234
$1^1D_2-2^3P_1$	5779·75	4	17297	17294
$1^3D_1-2^1P_1$	5192·29	4	19254	19260
$1^3D_2-2^1P_1$	5062·90	3	19746	19741
$1^1D_2-1^1F_3$	3560·75	6	28076	...
$1^3D_2-1^1F_3$	4174·38	4	23949	...
$2^3P_1-\alpha$	3832·94	10	26082	...
$2^1P_1-\alpha$	5003·59	3	19980	...
$1^3D_2-\beta$	4182·84	8	23903	...
$1^1D_2-\beta$	3567·16	3	28026	...

The term α above is probably 2^1D_2 term, while β is of the nature of an F term and is probably a^1F.

TABLE XV.—CONFIGURATIONS AND TERM VALUES FOR Tl. II & Pb. III.

Electron configuration.	Term.	Term values for Tl. II.	Term values for Pb. III.
$2\ P_1$	1^1S_0	164227	255216
$1P_11P_2$	1^3P_2	102499	176234
	$^3P_1$	111837	190829
	$^3P_0$	114784	194823
	1^1P_1	88565	159879
$1P_11P_3$	1^3D_1	47403	96272
	$^3D_2$	47797	97304
	$^3D_1$	48082	97785
	$^1D_2$	49064	101434
$1P_11Q_1$	1^3S_1	59008	105141
$1P_11R_1$	2^3S_1	...	57334
$1P_11Q_2$	2^3P_2	42199	79202
	$^3P_1$	44650	84143
	$^3P_0$	44866	84307
	2^1P_1	38020	78043
$1P_11Q_3$	2^3D_3	26023	53179
	$^3D_2$	26172	53628
	$^3D_1$	26300	53827
	2^1D_2	27333	58063
$1P_11P_4$	1^3F_4	(28000)	(64800)
	$^3F_3$	28114	65443
	$^3F_2$	28014	64941
	1^1F_3	...	73358
$1P_11P_5$	1^3G_5	...	36280
	$^3G_4$	...	36742
	$^3G_3$	...	37595

TABLE XVI.—OTHER UNCLASSIFIED MEMBERS OF Pb. III.

	1^3P_2	1^3P_1	1^3P_0
1.	1165·1 (10) 76447	995·8 (2) 91047	
2.	1073·1 (1) 93188	927·7 (3) 107794	894·4 (4) 111807
3.	1028·7 (10) 97210	894·4 (4) 111807	
4.	908·5 (0) 110072	802·07 124677	
5.	888·5 (3) 112549	786·48 (1) 127149	
6.	860·6 (0) 116200	764·57 (2) 130792	
7.	840·99 (5) 118908	749·09 (3) 133495	
8.	802·03 (5) 124684	718·07 (2) 139262	

Triplet number 7 is identified by Smith, recently as 1^3P–2^3S ; but the line 137491 classified by him as 1^3P_0–2^3S_1 is not recorded either by Carroll or Mack.

Spectrum of Pb. IV.

The first successful attempt to find series regularities among the wavelengths of trebly—ionised spectrum of lead, was that made by Carroll[8], who identified the first members of the principal and diffuse series occurring in the vacuum grating region. In a recent communication[16], the present writer set forth the leading members of the secondary series, which may be expected in the region of longer wavelengths.

The term structure of the spectrum of Pb. IV is generally similar in character to that of any chemically analogous atom or ion. Of these the spectra of Au I, Hg II and Tl. III and those of Ge IV and Sn IV have already been analysed to some extent. We have in the atom of Pb. IV, a one electron system, which normally gives the simplest type of alkali-like doublet spectrum. As the electron runs successively through P_1, P_2, P_3, Q_1 . . . shells, the terms 1, ^2S, 1 ^2P, 1 ^2D, 2 ^2S, etc., are obtained, the largest term being 1 $^2S_1$. The more complicated scheme of doublets and quartets result, when one or more of the inner group of 10 O_3, electrons is excited. The terms which different electron configurations give rise to may be calculated according to the principles developed by Pauli, Heisenberg & Hund and are given in the following table. It will be seen from the table that corresponding to the addition of an electron to the three different states (^1S, ^3D, ^1D) of the Pb V core, three distinct families of terms arise.

TABLE XVII.

K L M N	O					P			Term prefix.	Terms predicted.	Series limit Pb V term.
1_1.........4_4	5_1	5_2	5_3	5_4	5_5	6_1	6_2	6_3			
60	2	6	10			(1)			6s	^2S	^1S
60	2	6	10				(1)		6p	^2P	
60	2	6	10					(1)	6d	^2D	
60	2	6	9			1(1)			$6s^1$	^2D	^3D
60	2	6	9			1	(1)		$6p^1$	^4P D F	
										^2P D F	^3D
										^2P D F^1	
60	2	6	9			1		(1)	$6d^1$	^4S P D F G	^3D
										^2S P D F G	
										^2S P D F G^1	^1D

The analysis of Cu I Zn II Au I & Hg II has shown that in addition to the regular doublet systems built on the d^{10} ion there is another important family of terms built on the d^9s ion characterized by doublet and quartet terms The deepest term of this system is a metastable D term which is inverted and very low The separation of this deep lying D (d^9s) term can be found approximately by the relativistic doublet formula and by a knowledge of the D (d^9s) difference of the next higher ion As both these sources of information were available attempts were made to identify this inverted D term Further in Cu I Zn II Au I etc The metastable D term is found to combine strongly with the regular P term (d p) and with the quartet terms arising from the d^9sp configuration The recent analysis of the second spark spectrum of Thallium by the author has shown that these terms are found in the spectrum of Tl III[17] After the publication of the above mentioned report by the writer Smith published a preliminary report of a similar investigation where he suggests an alternative classification which without adducing any reasons he mentions as more probable From the application of the relativistic doublet law to isoelectronic spectra (Au I Hg II Tl III and Pb IV) and from a study of the progressive variation Δ Z in the homologous spectra C IV S IV Ge IV & Sn IV it was thought from the beginning of this investigation that $(2^2P_2—2^2P_1)$ should be of the order of 7 000±600 With the aid of the information available to the author regarding the stages of ionisation of the spectral lines in the visible and quartz regions a search was made for the frequency recurrence among the Pb IV lines and it was found that there were three alternative schemes as constituting the probable doublet systems with (2 P—2 P) = 6838 7131 8063 respectively It is the pairs of the wave-lengths with the last mentioned frequency difference that were given by Smith as the more probable. Relativity doublet sequence and progression of $\frac{\Delta}{Z}$ for the doublet separations are given in Tables XXI and XX The doublet systems classified by the writer are given in Table XXI

TABLE XVIII—PAIRS WITH FREQUENCY DIFFERENCES

6838	7131	8063
24139	23903	24683
30979	31037	32749
26730	25573	25229
33567	32704	33294
32362	34032	31780
39200	41162	39847
33007	36325	32548
39847	43458	40613

TABLE XIX—REGULAR DOUBLET SEQUENCE

	1 P_{12}	$\sqrt[4]{\Delta}$	2 $P_{12}\Delta$	$\sqrt[4]{\Delta}$
Au I	3815	7 859		
Hg II	91227	9 773	3672	7 76
Tl III	14811	11 031	5682	8 60
Pb IV	21060	12 047	7130	9 17

TABLE XX—VARIATION OF DOUBLET SEPARATION WITH Z

At. N Z	Element	2P—2P	Δ/Z^2	1P—1P	Δ/Z
6	C IV			107 4	2 983
14	Si IV	162	826	460 0	2 347
32	Ge IV	942	92	2790	2 726
50	Sn IV	2177 4	871	6507	2 602
82	Pb IV	7130	1 0	21060	3 130

TABLE XXI.—DOUBLET SYSTEMS OF Pb. IV.

	λ		ν	
$1^2S_1—1^2P_1$	1313·2	(9)	76150	21060
$—1^2P_2$	1028·7	(10)	97210	
$1^2P_2—1^2D_2$	1145·0	(3)	87336	21065
$—1^2D_3$	1116·2	(4)	89590	2254
$1^2P_1—1^2D_2$	922·5	(4)	108401	
$1P—2^2S$	1123·45	(3)	89012	21055
$1^2P_1—2^2S_1$	908·54	(5)	110067	
$2^2S_1—2^2P_1$	4182·40	(8s)	23903	7133
$—2^2P_2$	3221·00	(10)	31037	
$1^2D_2—2^2P_1$	3909·29	(5d)	25573	7131
$^2D_3—\ P_2$	3280·09	(9)	30478	2226
$^2D_2—\ P_2$	3056·84	(4)	32704	
$2^2P—2^2D_2$	2937·55	(4)	34032	868
$—\ D_3$	2864·45	(10)	34900	7130
$2^2P_1—\ D_2$	2428·70	(8bd)	41162	
$2^2P_2—3^2S_1$	2752·15	(1)	36325	7133
$P_1—3^2S_1$	2300·35	(4s)	43458	
$2^2D_2—2^2F_3$	3483·46	(9)	28699	875
$D_3—\ F_3$	3592·95	(6s)	27824	

In the first place it should be mentioned that 8,063 given by Smith as 2 $^2P_{12}$ is found to be abnormally high from the relativistic doublet sequence and from the progressive variation of $\Delta\nu/Z^2$ in the homolagous spectra, as shown in the preceding tables. Further, justification for the difference 7130, reported by the author is afforded by the location and identification of the following triplet as $6s^1\ ^2D$-$7p\ ^2P$.

TABLE XXII.

$d^{10}p/d^9s^2$	$^2D_3$	21019	$^2D_2$.
$^2P_1$	...		804·55 (1)
(7130)	...		124293
$^2P_2$	655·82 (3)		760·90 (0)
	152439		131420

There is no evidence of a similar combination with either of the remaining two separations. That the difference 21019 cm^{-1} represents the difference $^2D_3—\ ^2D_2\ (d^9s^2)$ of Pb. IV seems to be confirmed by the following comparison with $^3D_{13}\ (d^9s)$ of the next higher ion.

TABLE XXIII.

Cu.	Ag.	Zn.	Cd.	Tl.	Pb.	
2070	4574	2754	5764	18865	21300(?)	d^9s
2043	4472	2719	5635	18618	21019	d^9s^2

The combinations of this deep lying inverted D term with the quartet terms of the group (d^9sp) are given in the following table —

TABLE XXIV

6p /6	D	D
^4F		1407 8 (1) 71033
F	1749 9 (1) 57146	1279 5 (3) 78167
F	1439 2 (2) 69478	1104 8 (od) 90510
D		1308 2 (2) 76441
D	1437 1 (1d) 69585	1103 6 (od) 90613
D	1233 6 (3) 81068	979 47 (2) 102096
D	1096 5 (1d) 91189	
^4P	1362 60 (0) 73381	1059 3 (1) 94400
P	1087 34 (2) 91968	884 98 (6) 112997
P		

Summary and conclusions :

The spark spectrum of Lead has been photographed from λ7000 to λ2000 by using powerful excitation with a quartz spectrograph and a 10 feet concave grating using iron arc as the standard Many new lines have been measured mostly produced by the higher stages of ionisation The wave numbers wavelengths intensities together with the stages of ionisation of the prominent ones have been tabulated

A critical differentiation of the lines belonging respectively to Pb I Pb II Pb III Pb IV resulted from a careful scrutiny of the spectra obtained under varying degrees of excitation

The analysis of the second and third spark spectra of the element has been discussed in relation to the theoretical expectations and with the accurate and extensive data at hand it has been shown that the spectral structures of Pb III and Pb IV are in all details in complete agreement with Hund s correlation of spectral terms with electron configurations

The present analysis illustrates in a very convincing manner the utility of the study of the spectra of an element under varying degrees of discharge

In conclusion I wish to express my gratitude to Dr T Royds the Director of the Kodaikanal Observatory and to Dr A. L Narayan the Assistant Director for their active interest and much helpful criticism throughout the progress of the work My thanks are also due to the Syndicate of the Madras University for the award of a studentship which has made this work possible

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Explanation of plates.

I and II Spark Spectra of Lead, Concave Grating Spectrograph.

III and IV Spark Spectra of Lead, Quartz Spectrograph, with increasing inductance a, b, c, d.

KODAIKANAL,
22nd December 1930.

A. S. RAO,
Research Scholar.

PRICE, 8 *annas*] MADRAS : PRINTED BY THE SUPERINTENDENT, GOVERNMENT PRESS—1931.

Plate I.
Pb (conc. grating.)

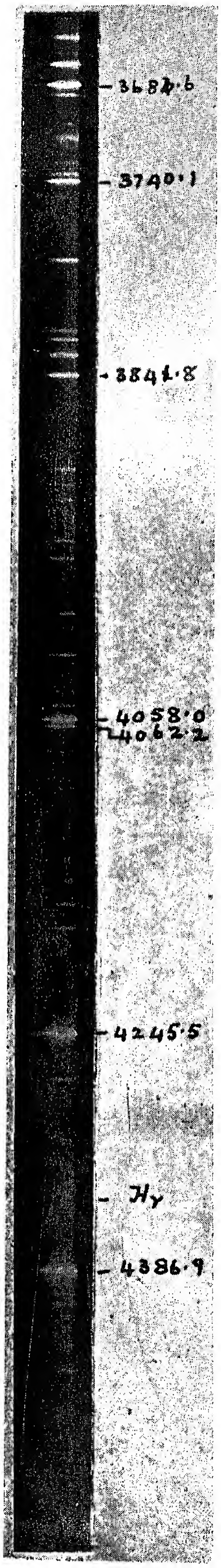


Plate II.
(Pb. conc. grating.)

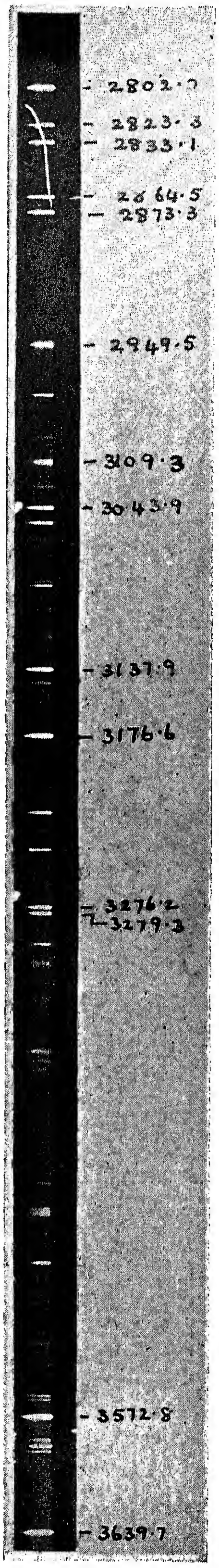


Plate III.
(Pb. quartz.)

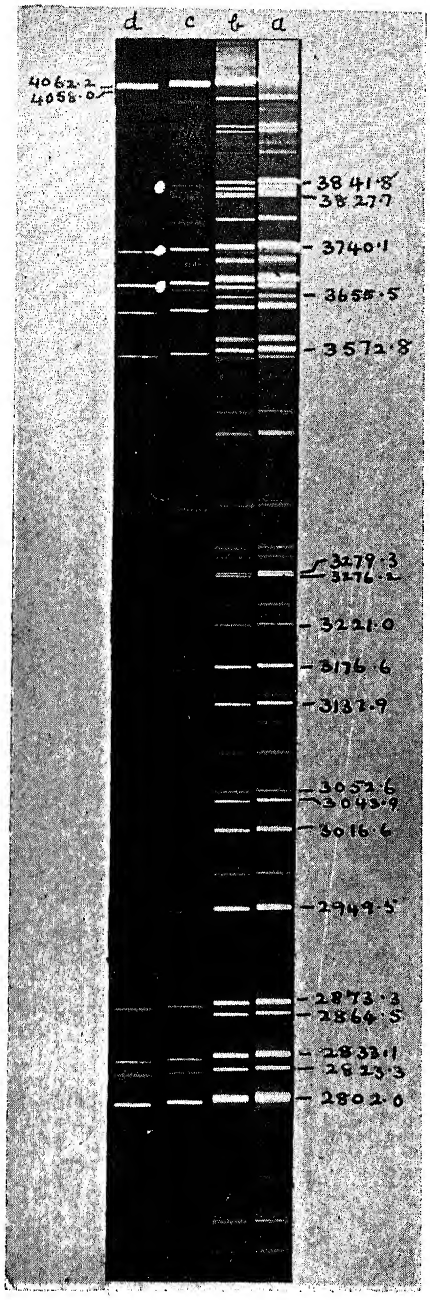
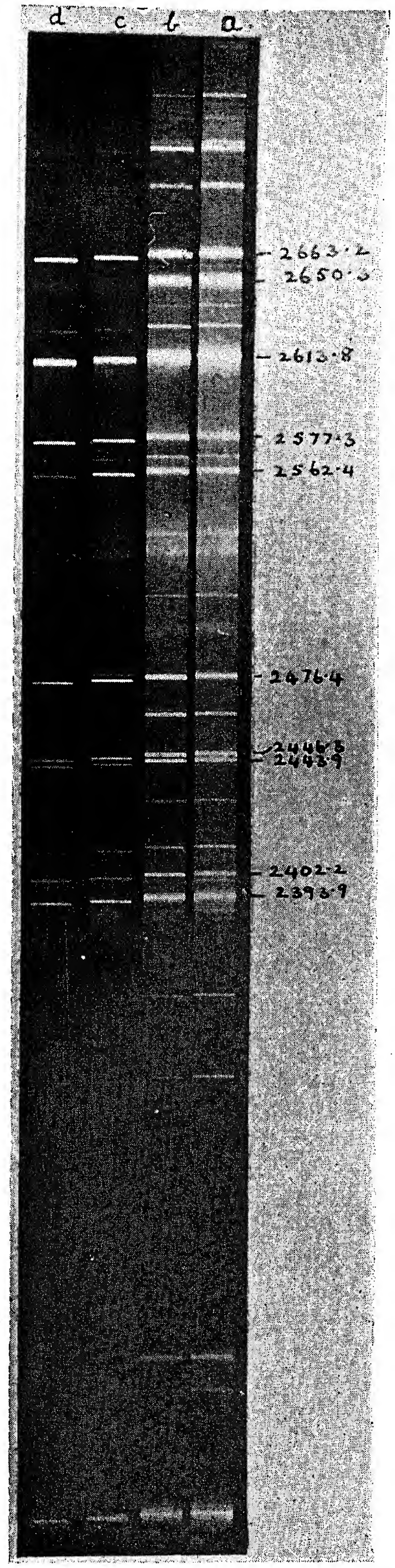


Plate IV.
(Pb. quartz—*cont.*)



Kodaikanal Observatory.

BULLETIN No. XCII.

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE SECOND HALF OF THE YEAR 1930.

In pursuance of the programme of work adopted since 1st January 1923 under the auspices of the International Astronomical Union, all observatories taking spectroheliograms of the sun have been asked to co-operate with the Kodaikanal Observatory by supplying copies of their photographs on those days when the Kodaikanal records are imperfect or wanting. In response to our requirements for the second half of the year 1930, the Mount-Wilson Observatory supplied calcium (K_{23}) prominence plates for 49 days and H*a* disc plates for 23 days, the Meudon Observatory supplied calcium (K_3) disc plates for 10 days and H*a* disc plates for 33 days and the Pitch Hill Observatory (Mr. Evershed's) at Ewhurst, Surrey, England, supplied one H*a* prominence plate and two H*a* disc plates.

When only incomplete or imperfect photographs for any day are available from more than one observatory, the best photograph is chosen as representing the solar activity of that day after weighting it according to its quality, and the remaining photographs are ignored.

Calcium prominences at the limb.

The mean daily areas and numbers of prominences photographed during the half-year by means of the K line of calcium are given below. The means are corrected for incomplete or imperfect observations, the total of 181 days for which plates were available being reduced to 156 effective days.

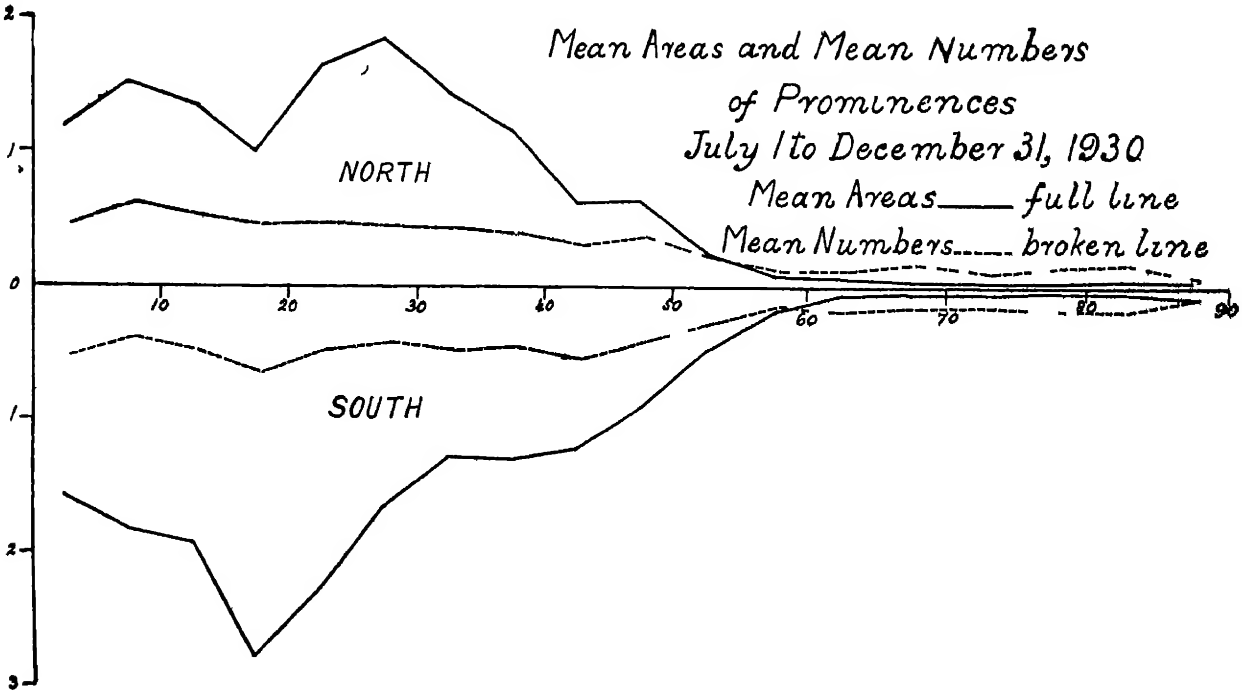
	Mean daily areas (square minutes).	Mean daily numbers.
North	1·31	5 71
South	1·76	6·08
Total	3·07	11·79

Compared with the first half of the year, areas show a decrease of 38 per cent, the decrease in the northern hemisphere alone being as large as 55 per cent, whilst numbers show a slight increase. As opposed to the previous half-year, activity now preponderates in the southern hemisphere.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 146 days of observation being counted as 125½ effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North (Kodaikanal photographs only)	1·36	6·26
South (do.)	1·96	6·64
Total	3·32	12·90

The distribution of prominences in latitude is represented in the following diagram in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude The ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line Apart from the general falling off of activity, the northern hemisphere shows a notable decrease in latitudes 15°—20° and 40°—60°, whilst the southern hemisphere shows a decrease between 20°—30° and an increase of activity in the belt 35°—60°



The monthly, quarterly and half-yearly areas and numbers, and the mean height and mean extent of the prominences on photographs from all the co operating observatories are given in Table I The unit of area is one square minute of arc The mean height is derived by adding together the greatest heights reached by individual prominences and dividing by the total number of prominences observed , the mean extent is derived by adding together the lengths of the base on the chromosphere of individual prominences and dividing by the total number of prominences

TABLE I —ABSTRACT FOR THE SECOND HALF OF 1930

Months	Number of days (effective)	Areas	Numbers	Daily means Areas	Daily means Numbers	Mean height	Mean extent
1930						"	°
July	24¼	83 4	302	3 4	11 1	29 9	5 08
August	25¼	60 9	263	2 4	10 3	30 6	4 80
September	27¼	72 0	284	2 6	10 4	29 6	4 81
October	25¾	83 0	264	3 2	10 2	34 8	5 51
November	25½	68 7	243	2 7	9 5	35 3	6 22
December	27¾	110 1	484	3 7	17 4	26 8	3 71
Third quarter	77	216 3	849	2 8	11 0	30 0	4 89
Fourth quarter	79	261 8	991	3 3	12 5	31 0	4 80
Second half year	156	478 1	1,840	3 1	11 8	30 6	4 84

Distribution east and west of the sun's axis.

Like the previous half-year, there is an excess of areas but a defect of numbers at the east limb, as will be seen from the following table :—

1930 July to December.	East.	West.	Percentage East.
Total number observed	893	943	48·64
Total areas in square minutes	251·2	226·9	52·54

Hydrogen prominences at the limb.

During the half-year photographs of the prominences in hydrogen light were taken in this observatory on 122 days which were counted as 113 effective days. The mean daily areas, in square minutes of arc, of hydrogen prominences are given below :—

	Mean daily areas (square minutes).
North (Kodaikanal photographs only)	0·48
South (do.)	0·66
Total ...	1·14

Compared with the previous half-year, Hα prominence areas show a decrease of about 49 per cent. The percentage of Hα areas to calcium areas has also decreased from 42 to 34. The curve of distribution of Hα prominences in latitude is similar to that of calcium prominences. As in the case of calcium prominences, the preponderance of activity is now in the southern hemisphere, the ratio of the southern areas to the northern being 1·38 and 1·44 for Hα and K prominences, respectively.

Metallic prominences.

Seven metallic prominences were observed during the half-year. Their details are given below :—

TABLE II.—LIST OF METALLIC PROMINENCES OBSERVED AT KODAIKANAL, JULY TO DECEMBER 1930.

Date.		Time I.S.T.		Base.	Latitude.		Limb.	Height.	Lines.
					North.	South.			
1930.		H.	M.	°	°	°		″	
July	8	8	54	2	10		W	10	5018·6, b_4, b_3, b_2, b_1, 5276·2, 5316·8, D_2, D_1.
September	14	9	4	2	14		E	15	4924·1, 5018·6, b_4, b_3, b_2, b_1, 5276·2, 5316·8, D_2, D_1.
	21	9	27	1	8·5		W	10	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1. 5363·0, D_2, D_1, 6677, 7065.
November	13	9	11	4	5		W	20	b_4, b_3, b_2, b_1, D_2, D_1 (faintly metallic).
December	22	8	55		5		W	15	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
		8	55		9		W	15	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677, 7065.
	26	9	6	4	45		W	30	b_4, b_3, b_2, b_1, D_2, D_1.

The distribution of metallic prominences was as follows —

	1 —10°	11°—20°	21°—30°	31°—40	41 —50°	Mean latitude	Extreme latitudes
North	5	1			1	13° 8	5° and 45°
South	—	—	—	—	—	—	—

One was on the east limb and six on the west limb

Displacements of the hydrogen lines

Particulars of the displacements observed in the chromosphere and prominences are given in the following table —

TABLE III

Date		Hour I.S.T.		Latitude		Limb	Displacement			Remarks
				North	South		Red	Violet	Both ways	
1930		H.	M.	°	°		A.	A.	A.	
July	7	8	56	26		W	0·5			At top
	8	8	54	10		W	1			Do
	13	8	40	1		W	1	2 5		To red at top, to violet at base
	14	8	48	10		W		0 5		At base
	17	9	50		88	W		Slight		
	21	8	58		16	E		1 5		At top
August	7	10	18		37	E	1 5			At top
	12	8	46	78		E	1			Do
	13	10	37		42 5	W	2			Do
	18	9	11		13	W		0 5		Do
	19	8	38	5		W		0 5		At base
	21	9	25	62 5		W	1 5			At top
	22	9	6	1		W	1			
	24	8	47	19		W		Slight		At base
	26	8	44	72 5		E		Do		Do
		8	46	69		E	0 5			At top
September	4	9	21	22		E	2 5			At base ; extends over 2 from 21° to 23°
		9	21	20		E		1		At top
	11	9	0		4 5	W	1 5			Do
		8	58		1	W		0·5		Do
	12	8	49	27		W		1		No prominence
		8	48	31 5		W		1		Do
	16	8	54		28	W	0 5	1		To violet at base, to red at top
		8	49	13		W	1 5			At top
	19	9	8	15		W	0 5			Do
	21	9	30	5		W	1			At base
		9	27	8 5		W	2			Do
	25	9	20	1		E		1 5		At top
		9	1		28	W	1			Do
	27	9	30	45 5		W	Slight			At base
		9	30	46 5		W		Slight		At top
October	2	9	50		30	W	1			At base
	3	10	46		13	W		1 5		At top
		9	6	47 5		W		1 5		No prominence
	8	9	2	4		W	1			At top
		9	2	10		W	1			At top, extends over 2° from 9° to 11°
		8	59	21		W		0 5		In chromosphere
	30	9	50	61 5		W	2			At top
		9	23	27		E	2 5			No prominence

TABLE III—*cont.*

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1930.		H.	M.	°	°		A.	A.	A.	
November	1	11	0	84		W		1		At top.
	9	9	35	54		W	1·5			Do.
	12	8	45		59	E		1		A floating filament, the whole displaced.
		8	36		65	E	0·5	1		To red at base ; to violet at top.
		8	34		69	E	1			At top.
		9	0		48	W		1		At base.
	13	9	27	47		E		2		At top.
		9	14		40	W	1·5			At top ; extends over 2° from 39° to 41°.
	14	9	0	13		W	1			At top.
	17	10	12		61	W	1·5			Do.
		10	8	48		W		0·5		At base.
	27	9	2	11·5		W		0·5		At top ; extends over 3° from 10° to 13°.
December	5	8	50	2		E	0·5			At top.
	6	9	22		3	E	1			No prominence.
		9	2	6		W	Slight			At top.
	13	10	26		9	E		1		Do.
		10	43	84		W	0·5			Do.
	14	8	54	8		E		1·5		Do.
		8	48	13		W	0·5			Do.
	15	8	54	18		E		Slight		At base.
	17	8	38	52		W		Do.		Do.
		8	45		88	W	0·5			At top.
	18	9	22		14	E	1·5			At top ; extends over 2° from 13° to 15°.
		8	52	77		W		4		At top ; extends over 2° from 76° to 78°.
	19	8	58	86·5		E		1		At top.
		9	12		2	W	1			Do.
	21	8	48	54		W		0·5		At base.
	22	8	47	70		E		0·5		Do.
		8	55	5		W	1·5	2·5		To red at top ; to violet at base.
		8	55	9		W		0·5		At base.
	26	9	6	45		W			2·5	At top ; extends over 4° from 43° to 47°.
		9	21		64	W	1			At top.
	27	9	28		27	E	0·5			
		9	17		15	W	1·5			At top.
	28	9	10	47		E	0·5			Do.
	31	9	21		7	W	1·5			Do.

The total number of displacements was 79 as against 197 in the first half of the year and their distribution was as follows :—

Latitude.	North.	South.
1°—30°	31	16
31°—60°	10	6
61°—90°	10	6
Total ...	51	28
East limb	...	24
West limb	...	55
Total ...	..	79

Reversals and displacements on the sun's disc

One hundred and thirty four bright reversals of the $H\alpha$ line, 129 dark reversals of the D_3 line and 25 displacements of the $H\alpha$ line were observed during the half-year Their distribution is given below.—

	North	South	East	West.
Bright reversals of $H\alpha$	80	54	78	56
Dark reversals of D_3	78	51	75	54
Displacements of $H\alpha$	14	11	15	10

Eighteen displacements were towards the red, 3 towards the violet and 4 both ways simultaneously

Prominences projected on the disc as absorption markings

Photographs of the sun's disc in $H\alpha$ light were available from Kodaikanal and the co-operating observatories for a total of 176 days, which were counted as 167 effective days The mean daily areas of $H\alpha$ absorption markings (corrected for foreshortening) in millionths of the sun's visible hemisphere and their mean daily numbers are given below:—

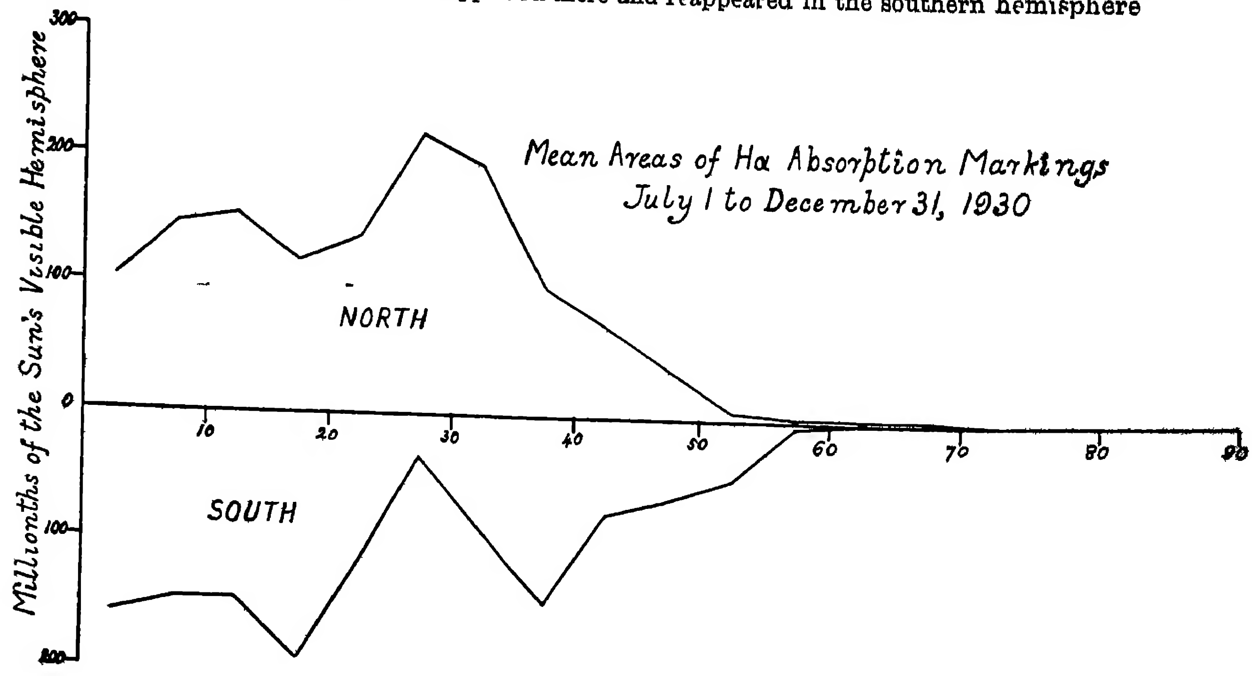
	Mean daily areas	Mean daily numbers
North	1,289	9 49
South	1,205	8 41
Total	2,494	17 90

The above show a decrease of 42 per cent in areas and 26 per cent in numbers, compared with the first half of the year The preponderance of activity in the northern hemisphere is maintained

For comparison with bulletins issued prior to the co operation of other observatories, the means based on Kodaikanal photographs alone are also given, 133 days of observation being reckoned as 120½ effective days

	Mean daily areas	Mean daily numbers
North (Kodaikanal photographs only)	1,302	9 44
South (do)	1,256	8 65
Total	2,558	18 09

The distribution of the mean daily areas in latitude is shown in the following diagram Except for a very low trough in the southern hemisphere near 30° the distribution is very similar to that of calcium and hydrogen prominences at the limb The activity near 50° which in the first half of the year was confined to the northern hemisphere has now disappeared there and reappeared in the southern hemisphere



The areas are equally divided between the eastern and western hemispheres, but the numbers show a slight western excess, with an eastern percentage of 49·3.

The areas of Hα absorption markings uncorrected for foreshortening are given below:—

	Mean daily areas.
North	797
South	700
Total ...	1,497

The uncorrected areas amount to 60 per cent of the corrected ones, a slight increase over the previous three half-years. The curve of distribution in latitude is similar to that for the uncorrected areas.

Thanks are due to the co-operating observatories for the photographs supplied by them.

KODAIKANAL,
8th October 1931.

T. ROYDS,
Director, Kodaikanal and Madras Observatories.

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Kodaikanal Observatory.

BULLETIN No. XCIII.

ROTATION OF Hα DARK MARKINGS NEAR THE EQUATOR COMPARED WITH OTHER DISC PHENOMENA.

BY

G. V. KRISHNASWAMI, M.A.

Abstract.—In Kodaikanal Observatory Bulletin No. 89, Dr. Royds has investigated the rotation of Hα dark markings, from the spectroheliograms of the years 1926—1929. Owing to the paucity of markings near the equator during that period much weight cannot be attached to the values obtained for latitudes less than 15°. In order to obtain reliable data for the rotation of markings near the equator, the Hα spectroheliograms for the eight years 1918—1925 have now been examined.

The results show that the speeds of rotation of Hα markings near the equator are in close agreement with the values of rotation of spots and that they are lower than those obtained from Doppler displacements of the Hα line by Adams. The polar retardation in the case of Hα dark markings is smaller than for sunspots. These results are in agreement with those of D'Azambuja for K_3 filaments.

Dr. Royds' values of heights of Hα dark markings near the equator have to be slightly modified in consequence of the more accurate determination of rotation now available. A revised table is appended.

Introduction.

Dr. Royds has recently determined the speed of rotation of Hα absorption markings by measurements near the central meridian for successive rotations of the same marking, basing his results on the Kodaikanal Hα spectroheliograms for the years 1926—1929.[1] Not many measures were possible in the belt between 0° and 15° owing to the paucity of markings of long duration there. Much weight could not therefore be attached to the values obtained in this belt as has been indicated by dotted lines in Fig. 1, Bulletin No. 89.

Material and method.

With a view to obtain more accurate data for this region the Hα spectroheliograms for the period 1918—1925 were examined. The life of each marking was traced in the solar charts of the Kodaikanal Observatory for at least a revolution and a half, from the time it first appeared on the eastern limb to its second disappearance at the western limb. A few could be followed for two or three rotations and more.

[1] Kodaikanal Observatory Bulletin No. 89. The rotation of hydrogen absorption markings and their height above the surface of the sun.

Out of 117 markings discussed 90 markings could be traced foi one rotation only 10 persisted for two rotations 1 for three and another for four rotations Each recuirent series of markings was then examined from the original photogiaphs when they were near the central meridian Measures were made on the western edge of the absorption markings and the longitudes of the points on the marking at 5 intervals of latitude were noted In very many cases the photographs of two successive days were measured and the mean of the results taken

The times of actually crossing the central meridian were deduced for intervals of 5 of latitude assuming the approximate value of 13 per day for synodic rotation to reduce the positions near the central meridian to the actual time of crossing it The synodic periods of each marking at the several points were thus obtained from which the synodic daily angular motion were easily calculated Adding to this the daily angular motion of the sun in longitude at the time of the year the sidereal daily angular motion at the several points is obtained.

Results

The mean of all such velocities at various latitudes for the several years and for the whole period is given in Table I The results for 1926—1929 are taken from Dr Royds measurements The numbers in the brackets indicate the number of markings used to obtain the mean The results do not vary greatly from marking to marking in the same latitudes nor from year to year The difference in the hemispheres is not also marked

TABLE I—DAILY ANGULAR SIDEREAL MOTION IN DIFFERENT LATITUDES ACCORDING TO HEMISPHERE AND YEAR

Year	0	5		10		15	
		N	S	N	S	N	S
1918	14 37 (9)	14 38 (11)	14 51 (2)	14 37 (10)	14 48 (1)	14 34 (9)	
1919	14 51 (6)	14 49 (8)	14 51 (5)	14 36 (6)	14 40 (3)	14 38 (4)	14 23 (1)
1920	14 39 (6)	14 40 (6)	14 33 (7)	14 34 (8)	14 39 (7)	14 28 (8)	14 30 (7)
1921	14 35 (5)	14 31 (2)	14 33 (9)	14 27 (4)	14 29 (11)	14 24 (5)	14 30 (10)
1922	14 30 (5)	14 35 (5)	14 33 (2)	14 40 (2)	14 38 (3)	14 55 (1)	14 45 (1)
1923		14 34 (3)		14 26 (3)		14 26 (3)	
1924					14 15 (1)		14 23 (1)
1925	14 41 (1)	14 30 (3)		14 24 (4)		14 14 (5)	
1926		14 41 (1)		14 32 (1)	14 45 (2)	14 24 (6)	14 42 (3)
1927	14 48 (1)	14 55 (1)	14 59 (1)	14 37 (7)	14 46 (2)	14 26 (9)	14 36 (2)
1928	14 50 (1)	14 40 (2)	14 47 (1)	14 28 (1)	14 44 (2)	14 23 (3)	14 43 (5)
1929	14 66 (1)	14 51 (4)		14 40 (4)	14 06 (1)	14 29 (7)	14 34 (3)
Mean	14 40 (35)	14 40 (46)	14 39 (27)	14 35 (33)	14 34 (50)	14 28 (60)	14 34 (33)

All tim we duced to d o mal f d y k ing from 8h I S T

Table II gives the mean values for the whole period at 5° intervals of latitude near the equator of the synodic period, daily synodic angular motion and daily sidereal angular motion. The motion is here assumed to be symmetrical with respect to the solar equator.

TABLE II.—MEAN ROTATION OF Hα ABSORPTION MARKINGS.

Latitude.	0°	5°	10°	*15°	*20°	*25°	*30°	*35°	*40°	Measures of all 15·1°
Number of markings ...	35	73	83	93	47	40	30	23	6	
Synodic period	26·83	26·85	26·95	27·05	27·22	27·38	27·54	27·81	27·86	27·11
Daily angular velocity synodic.	13·42	13·41	13·36	13·33	13·22	13·14	13·07	12·94	12·91	13·29
Daily angular velocity sidereal.	14·40	14·40	14·34	14·30	14·21	14·13	14·06	13·93	13·90	14·27

* From Table 1, Bulletin No. 89.

In Table III has been collected, for purposes of comparison, the speeds of rotation of the sun at different latitudes as obtained from various disc phenomena. The values given are (*a*) for the sunspots those derived from Greenwich observations of recurrent sunspots (M.N. 85, April 1925); (*b*) for the faculae, those derived from Greenwich measures of recurrent faculae as given by formula II which is more in accord with the observed data (M.N. 84, April 1924); (*c*)[3] for the Calcium filaments, the values obtained from the formula derived by D'Azambuja from recurrent K_3 filaments (C.R. 176, p. 950, 1923); (*d*) for spectroscopic results of the reversing layer[4] and the Hα line, the mean existing values (Handbuch-der Astrophysik, B.D. IV, ch. 2, ciph. 16, p. 169); and (*e*) for Ca prominences, the values obtained by Evershed (M.N. 89, January 1929). The speeds for the 5° zones have been computed, when necessary, as the mean of the speeds at the boundaries of the zone.

TABLE III.—VELOCITIES OF SOLAR ROTATION DERIVED FROM VARIOUS SOLAR PHENOMENA.

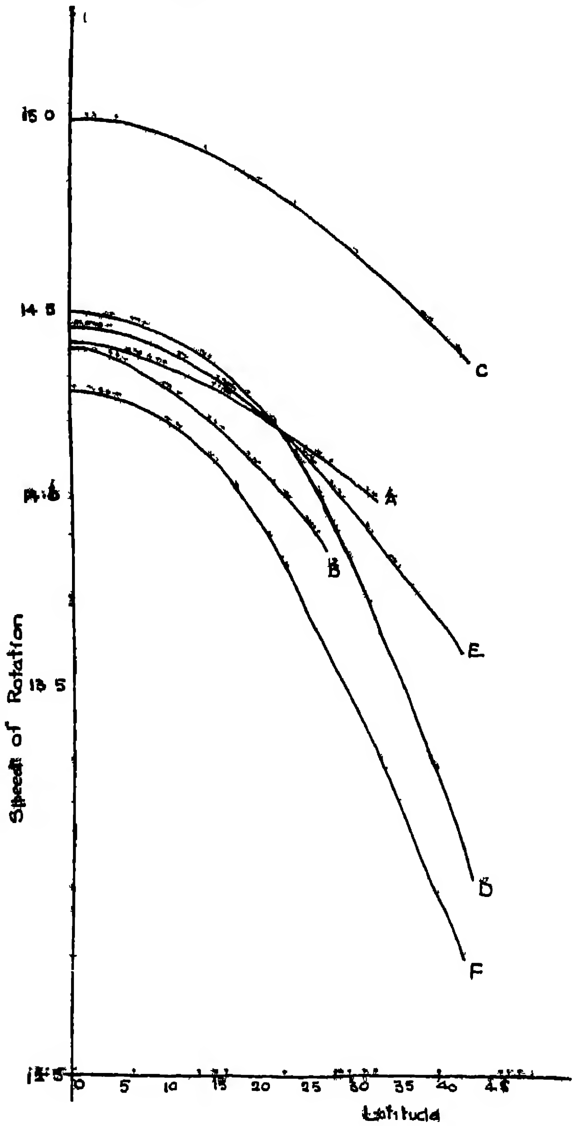
Daily sidereal motion. / Zone of latitude.	Hα dark marking.	Sunspots.	Faculae.	Calcium filaments.	Spectroscopic determinations.		
					Reversing layer.	Hα line.	K prominences.
0 ± 5 ...	14·40	14·39	14·49	14·45	14·27	15·00	......
± 5 ± 10 ...	14·37	14·33	14·46	14·42	14·26	14·98	17·1 (9°)
± 10 ± 15 ...	14·32	14·25	14·40	14·36	14·16	14·94	......
± 15 ± 20 ...	14·26	14·13	14·30	14·28	14·02	14·88	17·1 (18°)
± 20 ± 25 ...	14·17	14·01	14·16	14·17	13·83	14·80	
± 25 ± 30 ...	14·10	13·85	13·96	14·04	13·60	14·70	20·2 (25°)
± 30 ± 35 ..	14·00	...	13·71	13·89	13·35	14·60	......
± 35 ± 40 ...	...	...	13·39	13·75	13·07	14·48	16·6 (35°)
± 40 ± 45 ...	...	...	13·02	13·59	12·79	14·36	17·3 (51°)

[3] See Handbuch-der Astrophysik, B.D. IV, ch. 2, ciph. 10, p. 105.
[4] This includes perhaps the results of Abetti and Novokova at the mean epoch 1928·8. See Bulletin de la Societé Astronomique de France, Tome XLIV, 1930, p. 554.

The above values are represented graphically in Fig 1 It will be noticed that the speed of rotation of the Hα dark markings is practically the same as that of sunspots in the equatorial regions but is greater in higher latitudes The difference near the equator is practically zero and is about 0 25° per day in the zone 25°—30° From the closeness of the values of the speeds of rotation of sunspots and Hα dark markings near the equator it is to be inferred that these markings in the equatorial regions are anchored to the sunspots It would appear that this is not true in higher latitudes where the speed of rotation of Hα dark markings is higher than that of sunspots in corresponding latitudes

FIG 1

Comparison of speeds of rotation



A. Hα dark marking D Faculae
B Sunspots E Calcium filaments
C Hα line F Reversing layer

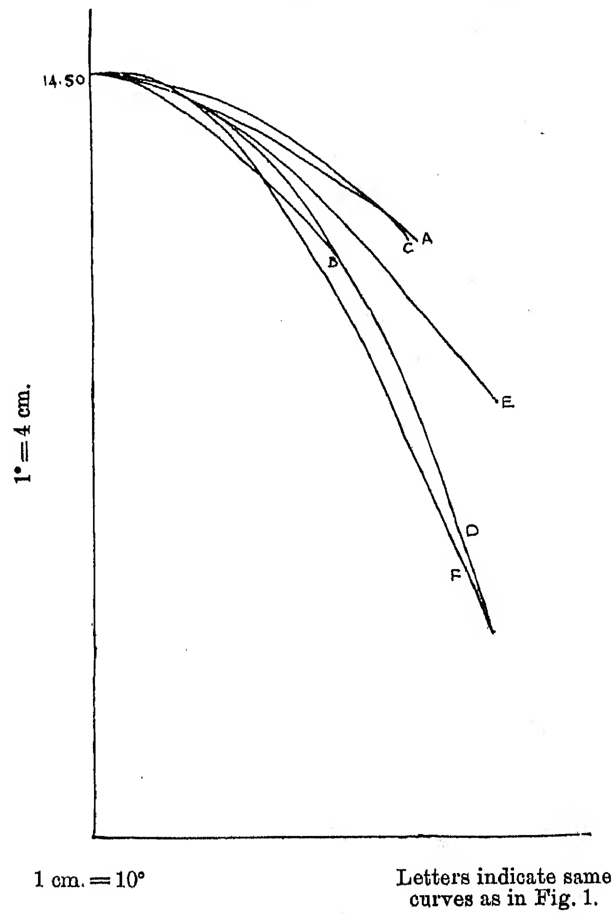
In order of increasing magnitude of equatorial velocities we have the reversing layer, sunspots, Hα dark markings, K dark markings, faculae, Hα line, and Ca prominences If, as is generally assumed, these dark

markings are projections of the prominences on the sun's disc then since Evershed has shown the velocities increase with levels, it appears that an absorption marking moves slower than the gases constituting the prominence which exhibits itself as that marking.

Fig. 2 shows graphically the law of the polar retardation corresponding to the various solar phenomena. A difference in the rate of change of angular velocity with latitude is indicated by a lack of parallelism in the curves. To show this more clearly the values have all been reduced to a common origin (14·50°), by the addition of some constant quantities to the results. The spots and the faculae give values which are practically identical throughout. Intermediate between these and the Hα dark markings are the K_3 filaments. The Hα dark markings and the Hα line are also nearly identical and show notably less equatorial acceleration. The H and K lines of the Ca prominences, as far as the results could be relied on, show the least polar retardation.

FIG. 2.

Comparison of polar retardations.



Heights of Ha absorption markings.

The values of h_1 and h_2 obtained by Dr. Royds require slight modification in view of the more reliable values now available for equatorial regions. The daily synodic rotation has been interpolated from Table II and λ is thence obtained. The values of ϕ have been taken as the means of the intervals and the heights deduced from the formula $2h = a \cos^2 \lambda \cos^2 \phi$ ($a = 960''$). The revised

values are given in Table IV The difference in the values of h and h is not veıy appr ciable and there is practically no change in the mean values The difference between h and h is also unaltered and so the main arguments of the paper continue to hold

TABLE IV—QUADRANTAL TIMES FOR Hα ABSORPTION MARKINGS AND THFIR CORRESPONDING HEIGHTS

Latitude	Number f mark g	Edg n ı th limb				Edg farthe f on th limb			
		Q adr tal tim T (d y)	ξ	λ	H ght h	Q d tal time T (d ys)	ξ	λ	H ight h
0— 5	6	45	13 42	73 1	40 5	5 47	13 42	73 4	39 1
6—10	1	5 30	13 38	70 9	50 4	5 42	13 38	72 5	42 6
11—15	19	5 59	13 34	74 6	32 1	5 74	13 34	76 6	24 5
16—20	29	5 54	13·26	73 5	35 0	5 (6	13 26	75 1	28 7
21—25	26	5 62	13 17	74 0	31 2	5 76	13 17	75 9	23 8
26—30	35	5 48	13 08	71 7	37 2	5 62	13 08	73 5	30 5
31—35	38	5 57	13 00	72 5	30 5	5 69	13 00	74 0	25 8
36—40	7	5 60	12 92	72 4	27 3	5 67	12 92	73 3	24 7
41—45	15	5 48	12 84	70 4	28 9	5 51	12 84	70 7	28 4
†27 3		W ght d m 5 5			33 4	W ght d m ans 5 650			27 9

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† Corr po ding t th w ghted m ns f s ϕ

In conclusion I wish to express my thanks to Dr Royds Director for permitting me to work in the Observatory for setting me on to work at this problem and for his valuable guidance and many suggestions

G V KRISHNASWAMI
Reader in Mathematics Annamalai University

5*th July* 1931

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Kodaikanal Observatory.

BULLETIN No. XCIV.

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE FIRST HALF OF THE YEAR 1931.

In pursuance of the programme of work adopted since 1st January 1923 under the auspices of the International Astronomical Union, all observatories taking spectroheliograms of the sun have been asked to co-operate with the Kodaikanal Observatory by supplying copies of their photographs on those days when the Kodaikanal records are imperfect or wanting. In response to our requirements for the first half of the year 1931, the Mount Wilson Observatory supplied calcium (K_{23}) prominence plates for 16 days and Hα disc plates for 4 days, the Meudon Observatory supplied calcium (K_3) disc plates for 3 days and Hα disc plates for 14 days.

When only incomplete or imperfect photographs for any day are available from more than one observatory, the best photograph is chosen as representing the solar activity of that day after weighting it according to its quality, and the remaining photographs are ignored.

Calcium Prominences at the Limb.

The mean daily areas and numbers of prominences photographed during the half-year by means of the K line of calcium are given below. The means are corrected for incomplete or imperfect observations, the total of 180 days for which plates were available being reduced to 171 effective days.

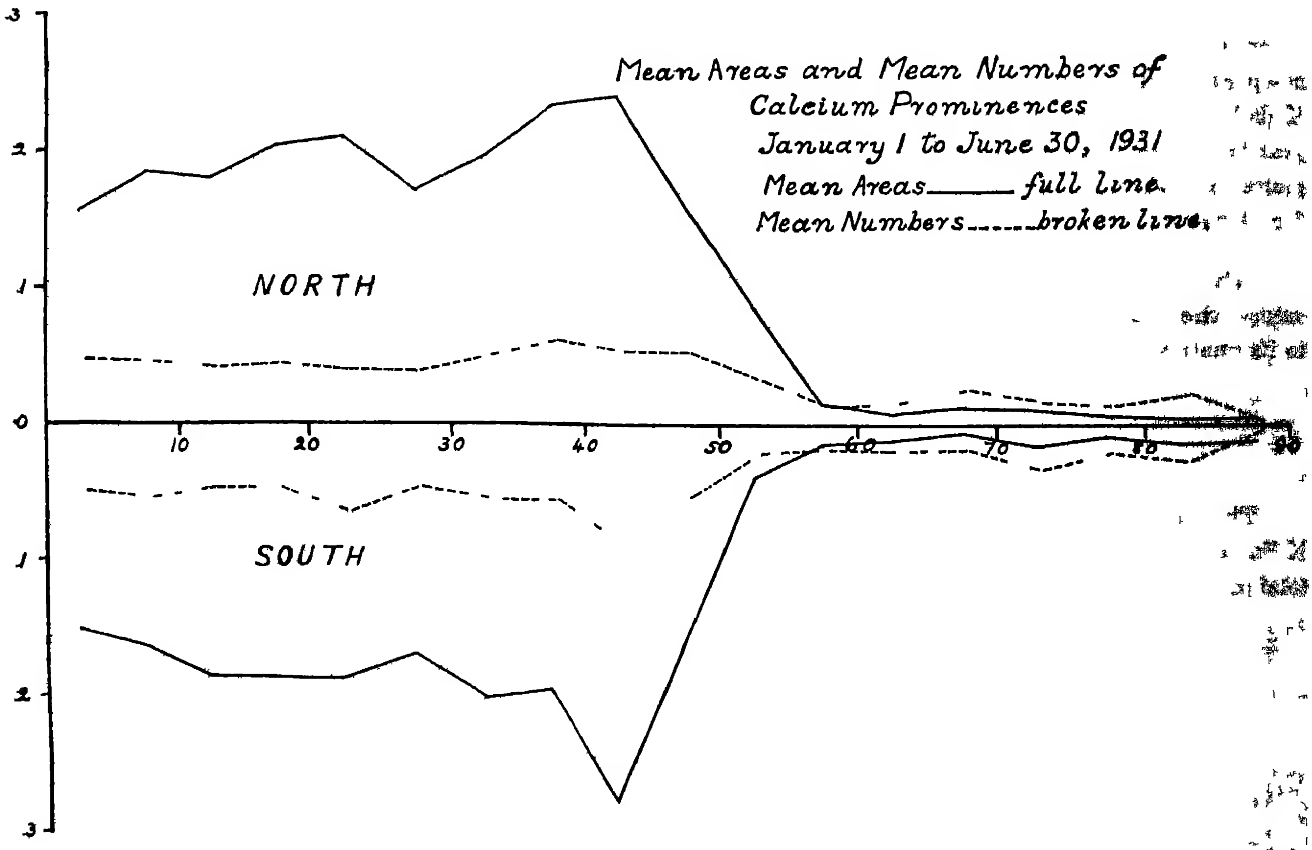
	Mean daily areas (square minutes).	Mean daily numbers.
North	2·11	6·60
South	1·98	7·09
Total ...	4·09	13·69

Compared with the previous half-year, areas show an increase of 33 per cent, the increase being greater in the northern hemisphere than in the southern, whilst numbers show an increase of 16 per cent.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 166 days of observation being counted as 159½ effective days

	Mean daily areas (square minutes)	Mean daily numbers
North (Kodaikanal photographs only)	2 18	6 78
South (do)	2 06	7 24
Total	4 24	14 02

The distribution of prominences in latitude is represented in the following diagram in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude. The ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line. The distribution of activity is very similar in both the northern and southern hemispheres, and differs considerably from that in the previous half-year The activity now increases from the equator up to latitude 45° and is very small beyond 55°



The monthly, quarterly and half-yearly areas and numbers, and the mean height and mean extent of the prominences on photographs from all the co-operating observatories are given in Table I The unit of area is one square minute of arc The mean height is derived by adding together the greatest heights reached by individual prominences and dividing by the total number of prominences observed, the mean extent is derived by adding together the lengths of the base on the chromosphere of individual prominences and dividing by the total number of prominences

It is seen that the increase in areas over the previous half-year is due to an increase in mean extent rather than to a change in the mean height of prominences.

TABLE I.—ABSTRACT FOR THE FIRST HALF OF 1931.

Months.	Number of days (effective).	Areas.	Numbers.	Daily means. Areas.	Daily means. Numbers.	Mean height.	Mean extent.
1931.						″	°
January	27¾	101·3	329	3·7	11·9	30·0	5·9
February	27½	131·2	410	4·8	14·9	31·0	5·9
March	31	129·9	466	4·2	15·0	32·3	5·3
April	27¾	118·6	414	4·3	14·9	28·6	5·4
May	28¼	122·1	370	4·3	13·1	32·8	5·6
June	28¾	93·9	351	3·3	12·2	29·4	5·3
First quarter ...	86¼	362·4	1,205	4·2	14·0	31·2	5·6
Second quarter ...	84¾	334·6	1,135	3·9	13·4	30·2	5·4
First half-year ...	171	697·0	2,340	4·1	13·7	30·7	5·5

Distribution east and west of the sun's axis.

Unlike the previous half-year, there is a defect of both the areas and numbers at the east limb, as will be seen from the following table :—

1931 January to June.	East.	West.	Percentage East.
Total number observed	1145	1195	48·93
Total areas in square minutes	329·0	368·1	47·20

Hydrogen Prominences at the Limb.

During the half-year photographs of the prominences in hydrogen light were taken in this observatory on 163 days which were counted as 148 effective days. The mean daily areas, in square minutes of arc, of hydrogen prominences are given below :—

	Mean daily areas (square minutes).
North	0·77
South	0·66
Total ...	1·43

Compared with the previous half-year, Hα prominence areas show an increase of about 25 per cent. The percentage of Hα areas to calcium areas is 34, as in the previous half-year. The curve of distribution of Hα prominences in latitude is similar to that of calcium prominences. The northern preponderance of activity is more marked for Hα prominences than for calcium ones, the ratio of the northern areas to the southern being 1·17 and 1·06 for Hα and K prominences, respectively.

Metallic Prominences

Twenty four metallic prominences were observed during the half-year Their details are given below —

TABLE II —LIST OF METALLIC PROMINENCES—JANUARY TO JUNE 1931

Date		Time LST	Base	Latitude North	Latitude South	Limb	Height	Lines (See note at end of table)
1931		H M	°	°			"	
January	18	11 15	1	9 5		W	10	1, 2, 3, 4 5, 7 8 9, 10
	19	10 0	4	5		W	10	1, 3, 4, 5 7, 8, 9, 10 11, 12
	20	8 50	4	4		W	10	3, 4, 7, 8, 10
	27	8 44		6		W	15	1, 2 3, 4 5, 7, 8 9 10, 11, 12
February	6	9 22		9		W	10	4 10
	14	9 40	2		4	E	10	1 2, 3, 4 9 10 11, 12
	22	9 27	5	10 5		E	15	1, 2 3, 4 9, 10, 11, 12
	27	9 33	4	10		W	35	1, 2, 3, 4, 9, 10, 11, 12
		9 35	2		1	W	15	1, 2 3, 4 9 10, 11, 12
		9 20	3	1 5		W	20	1 2, 3, 4, 8, 9, 10, 11
March	2	9 8	4	9		W	10	1 3, 4, 7, 8, 9 10, 11, 12
		9 5	3	17 5		W	15	1 3, 4, 8, 10
	14	8 49	3		11 5	W	10	1, 2 3, 4, 5, 7, 8, 9, 10 11, 12
April	10	9 37	3	18 5		E	30	1, 2, 3, 4, 9, 10, 11
		9 18	5	0 5		W	30	1, 2, 3, 4 8, 9, 10, 11, 12
	11	9 29		17		E	20	1 3, 4, 5, 7, 8, 9, 10, 11 12
	23	9 9	5	4 5		W	35	1, 2, 3, 4 5 6, 7, 8 9, 10, 11, 12 Also λ 5371 8
	24	9 27	2	8		W	20	1, 2 3 4, 9 10, 11, 12
May	19	8 51	4	6		W	15	1, 2, 3, 4, 5, 7, 8, 9, 10
	20	9 15	1	9·5		W	20	1 2, 3, 4, 5, 7, 8, 9, 10 11 12
		9 15	2	13		W	20	1, 2, 3 4, 5, 7, 8, 9, 10, 11 12
June	12	9 0	1	3 5		W	15	1, 2, 4, 8 9, 10, 11
	15	10 20	3		8 5	W	15	1, 2, 3, 4, 5, 7, 8, 9, 10 11, 12
	25	9 10	1	3 5		E	10	4, 10 (Faintly reversed)

NOTE —The key to the wavelengths of metallic lines is as follows —

No	λ	Element	No	λ	Element
1	4924 1	Fe +	7	5276 2	Fe + Cr
2	5016 0	He	8	5316 8	Fe +
3	5018 6	Fe +	9	5363 0	Fe +
4	b_4, b_3, b_2, b_1	Mg Fe +	10	D_2, D_1	Na
5	5234 8	Fe +	11	6677	He
6	5276 0	Cr	12	7065	He

The distribution of metallic prominences was as follows —

	1°—10°	11°—20°	Mean latitude	Extreme latitudes
North	16	4	5° 9	0° 5 and 18° 5
South	3	1	6° 2	1° 0 and 11° 5

Five were on the east limb and nineteen on the west limb.

TABLE III.—*Displacements of the hydrogen lines.*

Particulars of the displacements observed in the chromosphere and prominences are given in the following table :—

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1931.		H.	M.	°	°		A.	A.	A.	
January	1	9	43		17·5	E	1			At top.
		9	45		74	E	0·5			No prominence.
		9	32	11		W	1			At top.
		9	32	16		E	1·5			Do.
	2	9	16	83		E		0·5		No prominence.
		9	18	53·5		W	1			At top.
	3	9	25		32	E	0·5			Do.
	8	10	40		56·5	W	1·5			Do.
		10	34		1	W	2			At base.
	10	9	4	33		E	0·5			Do.
		9	11		64·5	W	0·5			At top.
		9	18	54		W		Slight		At base.
	19	9	55	3·5		W	1·5			At top; extends over 3° from 2° to 5°.
		9	55	4		W		0·5		At base.
	22	9	20		11·5	W	0·5			Do
		9	16	50		W	1·5			At top.
	23	9	33	16·5		E	0·5			Do.
		9	38		34	E		0·5		Do.
	26	9	4	29		W	0·5			Do.
	27	8	51	6·5		E	0·5			Do.
		8	44	6		W	1			Do.
	28	9	27		5	W	2			Do.
		9	30	11·5		W	1			Do.
	29	9	6		3·5	E	Slight			No prominence
		9	7		11	E	1·5			At top.
		9	10		41	W	Slight			Do.
		8	55	21·5		W	1			Do.
	30	9	5		80	E		1		Do.
		8	55		76·5	W		Slight		No prominence.
		8	48	39·5		W	1·5			At base
	31	9	25		11	E	2·5			At top.
		9	7	71		W	1·5			Do.
February	1	9	35	8		E	0·5			At top; extends over 4° from 6° to 10°.
		9	38		39·5	E		1		At top; extends over 4° from 38° to 42°.
		9	17	3		W	1			At top; extends over 4° from 1° to 5°.
		9	10	56		W		1·5		At top.
	2	9	9	11		E	0·5			At base.
		9	1		8	W	Slight			
	4	8	42	48·5		W	0·5			At top.
	5	9	20		38	E			1	At base.
		9	8		36	W		2·5		At top.
	6	9	22	9		W			1	
	7	9	17		11	E		0·5		At top.
		9	1	30		W	Slight			Do.
		9	0	60·5		W	1			
	9	9	14	8		E	0·5			At base.
	11	9	24		37·5	E	2			Do.
	12	9	36	17		E	1			No prominence.
		9	22	2		W	Slight			At top.
		9	16	22		W			1	At base.
		9	19	56·5		W		1·5		At top.
	13	9	56	19		E	1			~~At base.~~
		10	0		21	E	0·5			Do.
	14	9	7	66		E	Slight			
		9	40		4	E	1·5			At top.
		9	12	45·5		W	1			Do.
	15	10	7		75·5	W		2		At base.
		10	3	5		W		2·5		At top.
	16	8	59	7		E	Slight			At base.
	17	8	50		47·5	E	Do.			Do.

2

Date		Hour L.S.T.		Latitude		Limb	Displacement			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1931		H	M				Å	Å	Å	
February	17	8	44	48.5		W	Slight			At base
	19	9	27		61	E	0.5			No prominence
		9	27		74.5	E	2			Do
		9	28		78.5	E	0.5			Do
		9	10		9	W		Slight		Do
		9	5	55.5		W	1			At top
		9	3	74		W	Slight			No prominence
	20	9	2	4		E	Slight			At top
		8	59		40.5	W	0.5			Do
	21	8	45	40.5		E	1			Do
		8	52		26	W	0.5	1		To red at top to violet at base.
	22	9	27	10.5		E			0.5	At base extends over 5 from 8° to 13°
		9	15		5	W	1.5			At top
		9	3	15		W		1		At base
	25	8	52	72		E	0.5			At top
	26	9	28	1		E	1.5			Do
		9	11	14		W		4		D
		9	0	80		W	0.5			Do.
	27	9	45	25		E		Slight		
		9	47	18		E	1			At top
		9	48		21	E		1		Do
		9	35		1	W			1	Do
		9	33	10		W	1			At top extends over 4° from 8° to 12°
		9	25	43.5		W		Slight		No prominence.
	28	9	24		7.5	W		2		At top
		9	3		4	W	1			Do
		9	20	1.5		W	1	2		Both at top; extends over 5° from 0 to 5°
		9	55	67		W		Slight		
		9	54	81		W	Slight			No prominence.
March	3	8	58	47.5		W	1.5			At top
	4	8	50	21		W		1.5		At base
	5	9	28	36.5		W		Slight		No prominence
	6	9	12	63		E		0.5		At top.
	9	9	50	18.5		E			1.5	At top extends over 5° from 16° to 21°
	10	10	36	13		W		1.5		At base
	11	9	20		11	W	0.5			At top
		9	15		1.5	W	Slight			Do
	13	8	52	41.5		E		0.5		
		9	0	3		E	Slight			At base
	14	8	49		14	W	1			At top
	15	9	32	41.5		W	Slight			Do
		9	30	60		W		1.5		At base
	16	9	0		37	W		0.5		Do
	17	8	41	22		E	1			
	19	8	53		6	W	1	Slight		To red at top to violet at base.
	20	8	48	40		E		0.5		At base
	22	8	58		20	E		0.5		Do
		8	50		1	W	1.5			
	25	8	46	39.5		E	0.5			At top
		8	58	5		E		1		At base
		8	50	7		W	1.5			At top
	26	9	8	11		W		0.5		At base
	27	9	32	63		E		Slight		
		9	56		55.5	E	1.5			At base.
	28	8	58	27		W	1			At top.
	29	8	58		22	E		0.5		At base.
April	2	8	34		15	W		3		At base
	3	8	45		11	E		0.5		Do.
	4	8	56	18		E	1.5			Do
	6	8	43		69	W	0.5			At top
	7	8	53	41.5		E	1			At base
		8	55	11		E	1			Do

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North	South		Red.	Violet.	Both ways.	
1931.		H.	M.	°	°		A.	A.	A.	
April	7	8	47		18	W	1	0·5		To red at top, to violet at base.
	8	10	31		2	E	2			At base.
	9	10	45		32	E		1		At top.
		9	15		34	W			Slight	
		9	2	24·5		W	2·5			At top.
	10	9	5	43		E			light	Do.
		8	55	26		E		0·5		Do.
		9	40	6		E		0·5		Do.
		9	28		42	W	1	1·5		To red at top, to violet at base.
	11	9	55	49·5		E	1			At base.
		9	51	47		E		6		At top; extends over 5° from 45° to 50°.
		9	46	26		E	2			
		9	21	8		E			Slight	At top.
		9	17		9	E	1			No prominence.
		9	14		21	E	1			At base.
		9	14		22	E		2		At top.
		10	2		2	W	1			
		10	12	39·5		W	1			At top.
	15	9	17	59·5		E	0·5			At base.
		9	15	45·5		E		2		At top.
	18	8	40	70		E		Slight		
	21	8	52	78		W	0·5			At top.
	23	9	10	4·5		W			1	At base.
		9	9	14		W		1		At top.
	24	9	37	60·5		E			1·5	
		9	27	8		W			1	
		9	21	20		W	1			At base.
		9	19	52·5		W		4		At top.
	25	9	25	11·5		W	2			Do.
May	1	9	22	50		E	Slight			
	2	9	17		2	E	0·5			No prominence.
		9	0		9	W	1·5			At top.
	6	9	20	10		E	1	1		To red at base, to violet at top.
	7	9	13	12·5		E	Slight			No prominence.
		9	14	3		E		1·5		At top.
		9	18		34·5	E		1		Do.
	8	9	14		11	W	2			At base.
	15	8	50		26	W	Slight			Do.
	17	9	35	53		W	Slight			
	19	8	51	7		W		0·5		At base.
	20	9	5		2	W	Slight			At top.
		9	20	67		W	0·5			Do.
		9	20	70		W	Slight			Do.
	26	9	14		43	W		1		At base.
	27	9	35		34	E	0·5			No prominence.
		9	14		8	W	1	1		To red at top, to violet at base.
	29	9	56	·5		E		1·5		At top.
June	2	8	50	10		E	0·5			At base.
		8	45	6		W		1		Do.
	9	9	16		17	W	1			At top.
	11	9	32		46	E		0·5		At base.
		9	8	7		W		1		At top.
	12	9	0	3·5		W			0·5	
	13	9	2	33		E	Slight			At top.
	15	10	20		9	W	1·5	1		To red at top, to violet at base.
	16	8	58		9	W	1·5			At top.
		8	58		7	W		0·5		At base.
	24	9	16		44	E	2			Do.

The total number of displacements was 188 as against 79 in the second half of the previous year and their distribution was as follows —

Latitude		North	South
1°—30°		63	48
31°—60°		33	21
61°—90°		15	8
	Total	111	77
East limb			83
West limb			105
	Total		188

Reversals and displacements on the sun's disc

Two hundred and twenty one bright reversals of Hα line, 208 dark reversals of the D_3 line and 28 displacements of the Hα line were observed during the half-year Their distribution is given below —

	North	South	East	West
Bright reversals of Hα	148	73	104	117
Dark reversals of D_3	139	69	98	110
Displacements of Hα	22	6	12	16

Twenty displacements were towards the red, 6 towards the violet and 2 both ways simultaneously

Prominences projected on the disc as absorption markings

Photographs of the sun's disc in Hα light were available from Kodaikanal and the co-operating observatories for a total of 180 days, which were counted as 178 effective days The mean daily areas of Hα absorption markings (corrected for foreshortening) in millionths of the sun's visible hemisphere and their mean daily numbers are given below —

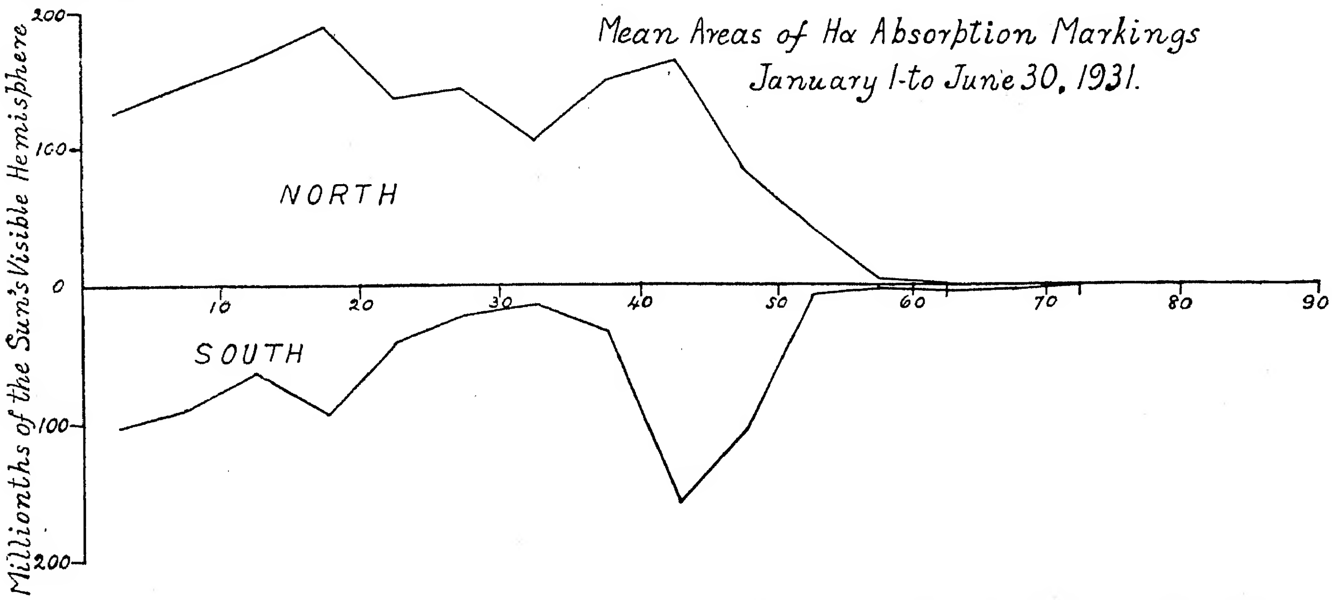
		Mean daily areas	Mean daily numbers
North		1,447	9 65
South		743	5 61
	Total	2,190	15 26

The above show a decrease of about 12 per cent in areas and 15 per cent in numbers, compared with the previous half year The decrease has been confined to the southern hemisphere namely 38 per cent and 33 per cent for areas and numbers respectively

For comparison with bulletins issued prior to the co operation of other observatories, the means based on Kodaikanal photographs are also given, 165 days of observation being reckoned as 161¾ effective days.

		Mean daily areas	Mean daily numbers
North (Kodaikanal photographs only)		1 430	9 64
South (do)		715	5 38
	Total	2,145	15 02

The distribution of the mean daily areas in latitude is shown in the following diagram. In contrast to the distribution of prominences at the limb there is a minimum of activity near 30°, particularly marked in the southern hemisphere.



The numbers are almost equally divided between the eastern and western hemispheres, but the areas show a slight eastern excess, the percentage east being 51·7.

The areas of Hα absorption markings uncorrected for foreshortening are given below :—

	Mean daily areas.
North	804
South	424
Total ...	1,228

The uncorrected areas amount to 56 per cent of the corrected ones, as against 60 per cent for the previous half-year. The curve of distribution in latitude is similar to that for the uncorrected areas as usual.

Thanks are due to the co-operating observatories for the photographs supplied by them.

KODAIKANAL,
27th January 1932.

T. ROYDS,
Director, Kodaikanal and Madras Observatories.

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Kodaikanal Observatory.

BULLETIN No. XCV.

PROMINENCES AND RADIATION PRESSURE

BY

T. ROYDS, D.Sc.

Abstract.—Daily spectroheliograms of calcium and hydrogen prominences are available at Kodaikanal from the end of 1928. Comparison shows that quiescent prominences are of essentially the same form and height in both calcium and hydrogen, as has been concluded by other observers. This is also true of eruptive prominences in which hydrogen partakes of the upward motion evidenced in calcium. Since radiation pressure is only considerable in the case of Ca+ atoms, this evidence is opposed to the theory of radiation pressure as the force supporting prominences and driving eruptive prominences away from the sun.

There appear to be differences in the relative brightness of the K line and the Hα line in different prominences, and frequently in different parts of the same prominence. Owing to the effect of Doppler displacements, it is not possible for spectroheliograms to give conclusive evidence as to whether these variations in brightness are really due to varying proportions of the numbers of Ca+ and H atoms.

It is pointed out that estimates of the amount of radiation pressure on Ca+ atoms should take account of the radiation in the reversals of the Ca+ lines. These estimates must await photometric measures in the Ca+ lines.

Introduction.—The only theory which can in any satisfactory way explain the existence of the chromosphere and of the prominences is that of Milne * who showed that selective radiation pressure may be large enough to support atoms which have their resonance line in a part of the spectrum where the sun is radiating strongly. In this way he has successfully explained the formation of a chromosphere of ionised calcium, of prominences of ionised calcium, and has also given an explanation of the enormous velocities occasionally attained in eruptive prominences, a problem which, till then, had baffled solution. Notwithstanding these notable successes of Milne's theory, it does not suffice to give a complete explanation of the observations made on the sun's chromosphere and its prominences. It is observed that Ca^+, H and He are always present in the chromosphere, reaching almost to the same heights, and that prominences invariably exhibit the lines of these three elements. It is extremely improbable that the radiation pressures exerted by sunlight on the atoms o Ca^+, H and He and the masses of these atoms are also so nicely adjusted that the atoms of these three elements are delicately balanced together at the same heights above the sun's surface. Indeed Gurney† has already pointed out that the radiation pressure on hydrogen is 10^5 times smaller than on ionised calcium, and on helium 10^{13} times smaller. Electrical forces may be ruled out as they would not operate on neutral hydrogen and helium. Turbulence has also been invoked‡, but there are serious objections to the magnitude of the velocities which have to be postulated.

Recent Observations.—The question of the forms and brightness of prominences in different spectrum lines has occupied the attention of solar observers from almost the beginning of the observation of prominences, but the question has attracted more attention recently with a view to elucidating the nature of the

* Milne, M.N., R.A.S., 84, 354—1924; 85, 111—1924; 86, 8—1925; 86, 578—1926 and 87, 459—1926.
† Gurney, M.N., R.A.S., 88, 377—1928.
‡ McCrea, M.N., R.A.S., 89, 483 and 718—1929.

forces at play. Perepelkin* finds that the ratio of intensities $H\alpha$: D_3 decreases with height in prominences. Minnaert and Slob's measures† do not agree with Perepelkin's, and the former interpret the varying ratio by varying self-absorption of $H\alpha$. They have also measured the intensity ratios of H : K and of $H\gamma : H\delta : H\epsilon$. Slob‡ has continued observations of the ratio of H : K and finds a value decreasing with height, instead of Minnaert and Slob's constant ratio.

Pettit§ has compared spectrohelioscopic observations of prominences in $H\alpha$ with spectroheliograms in calcium K line, observing mainly quiescent prominences and those active ones which were drawn to an area of attraction on the sun's surface. He finds that prominences generally show the same form in $H\alpha$ as in K, even to considerable detail, except that moving streamers and knots in the active prominences are either absent in $H\alpha$ or only represented by thin lines where there are broad ribbons in K. He interprets these differences as evidence that the attractive force is electrical in origin and he also finds evidence of repulsive electrical forces.

Perepelkin‖ has also discussed the radial velocities of prominences, their form and intensities in different spectral lines. He finds that radial velocities decrease in the order Ca^+, H, He; in most cases prominences have the same form in Ca^+, H and He but in other cases the extents vary in the following decreasing order Ca^+, H, He, metallic lines; also that the ratio of intensities of the lines $H\epsilon : H$ is very variable, in the average 0·37, and decreasing with increasing radial velocity. He concludes that radiation pressure must play an important role in the production of prominences although quiescent prominences cannot be caused by radiation pressure.

Kodaikanal Spectroheliograms.—New material for the study of the forms and heights of prominences in calcium and hydrogen has been obtained at the Kodaikanal Observatory from the end of 1928. Owing to the increase in the sensitiveness of panchromatic plates about that time, it became practicable to photograph the $H\alpha$ prominences by means of the Kodaikanal $H\alpha$ spectroheliograph with reasonable exposure times. Since January 1st, 1929, the daily observing programme has been extended to include one $H\alpha$ prominence photograph. The solar diameter on both $H\alpha$ and K images is about 60 mm. The material studied for this bulletin comprises the $H\alpha$ and K spectroheliograms of the limb of the sun from the beginning of October 1928 to the end of 1931. Whenever possible, on each day a K prominence plate is taken first, then an $H\alpha$ photograph and finally another K photograph. In this way it is possible, by comparing the two K photographs, to be certain what changes have taken place in the prominence before drawing conclusions as to the differences of form and height in $H\alpha$ as compared with K. Of course, simultaneous photographs would be still better but this is not possible with the instrumental equipment at Kodaikanal. Yet it is considered that the study of alternate photographs is infinitely better than a comparison of a drawing in $H\alpha$ with a K photograph. The interval between successive photographs is often not more than 10 minutes, and in the majority of cases the changes in prominence form in this interval are trifling. The time occupied in taking the photographs does not permit of this interval being shortened appreciably.

Properties of Photographic Plates.—Before drawing definite conclusions regarding the differences in apparent brightness of different parts of prominences in Ca^+ and $H\alpha$ photographs, it has to be remembered that these photographs are not taken on the same kind of plates. For Ca^+ prominences, rapid plates of the ordinary type are used, whereas for $H\alpha$ prominences rapid panchromatic plates are employed. These two kinds of plates do not have the same characteristic properties. A study of their characteristics has been made with light of the same wavelength to which they are exposed in the spectroheliographs, the photometric measures being made with a Hartmann photometer. The photometric plates were treated and developed in a manner as similar as possible to the spectroheliograms. It is found that the gamma values of the panchromatic plate exposed to $H\alpha$ light is nearly three times that of the ordinary rapid plate exposed to K light. This has an important bearing on the interpretation of the fainter parts of a prominence. On

* Perepelkin, Z.f. Physik 49, 295.
† Minnaert and Slob, B.A.N. No. 187, 176—1930.
‡ Slob, B.A.N. No. 218, 120—1931.
§ Pettit, Publ. A.S. Pacific 68, 207—1931.
‖ Perepelkin, Z.f. Astrophysik, 3, 338—1931.


Fig. 7. Ca.


Fig. 8. Ca.

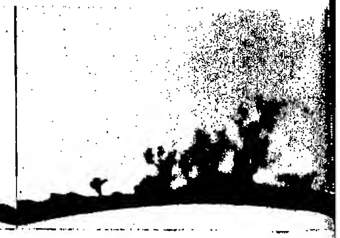
Fig. 8. Hα.


Fig. 7. Hα.


Fig. 9. Ca.


Fig. 9. Hα.

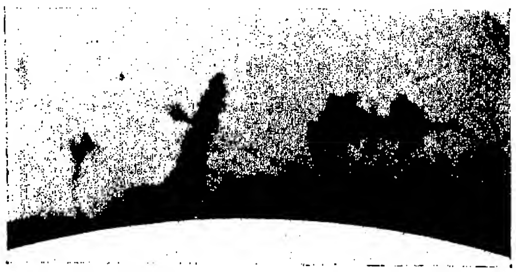
Fig. 10. Ca.


Fig. 11. Ca.

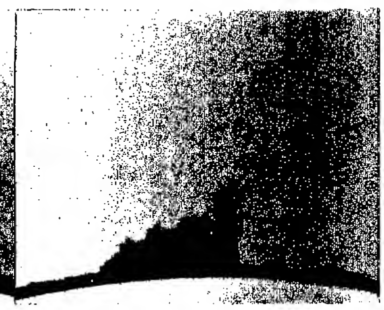
Fig. 11. Hα.

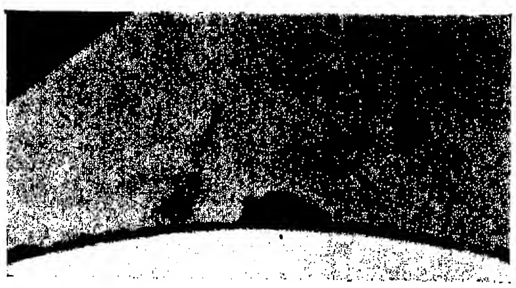
Fig. 10 Hα.

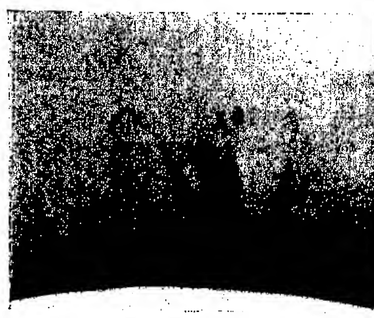
Fig. 12. Ca.

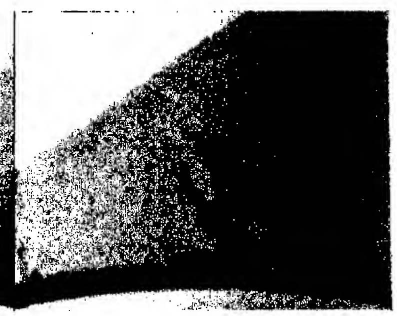
Fig. 12 Hα.


Fig. 13. Ca.


Fig. 13. Hα.


Fig. 14. Ca.

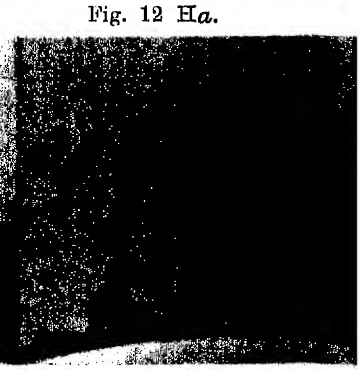
Fig. 14. Hα.

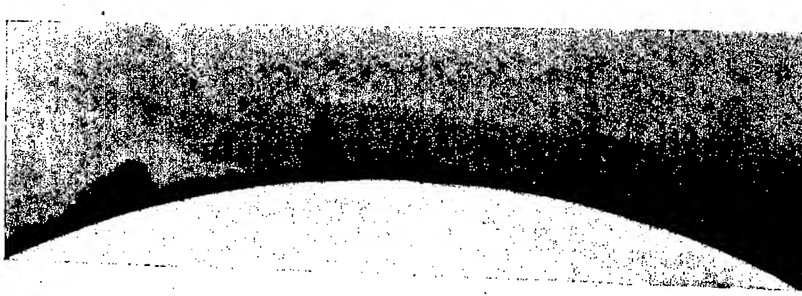
Fig. 15. Ca.

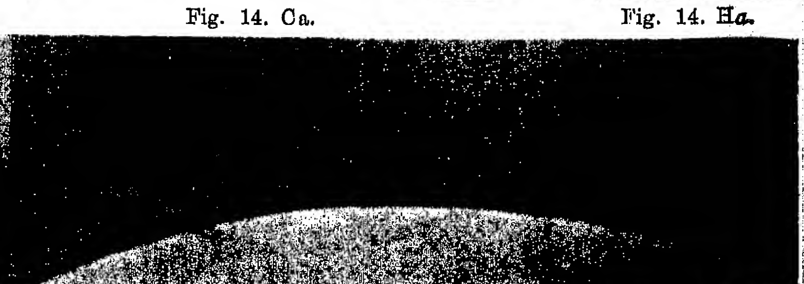
Fig. 15. Hα.

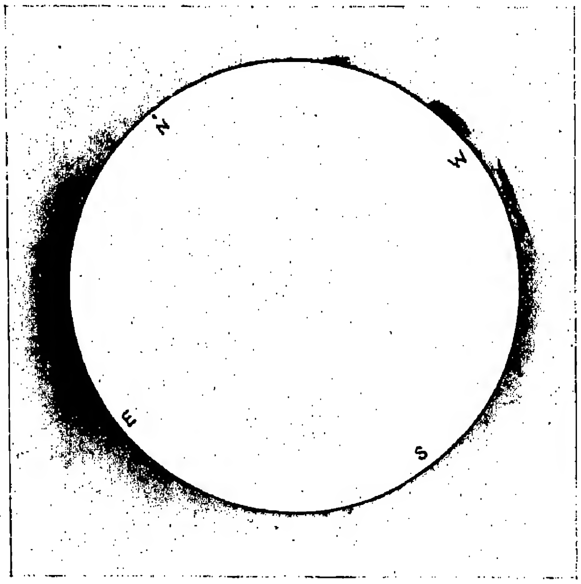

Fig. 1. Ca.

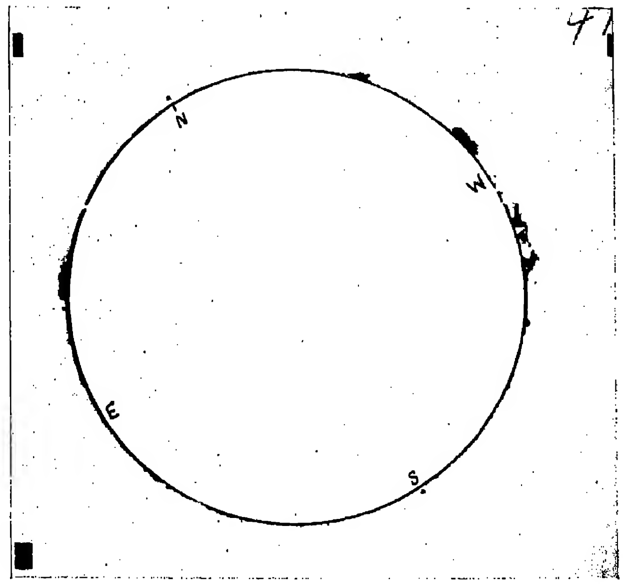

Fig. 1. Hα.

Fig. 2. Ca.

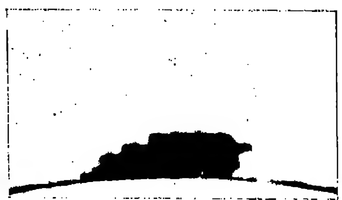

Fig. 2. Hα.

Fig. 3. Ca.

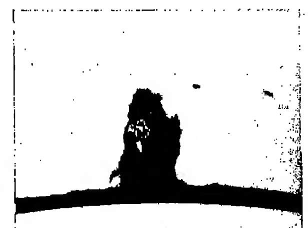

Fig. 3. Hα.

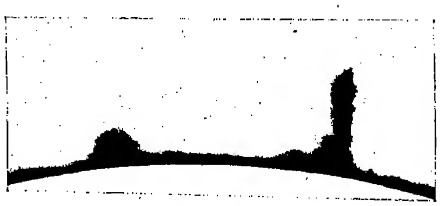

Fig. 4. Ca.

Fig. 4. Hα.

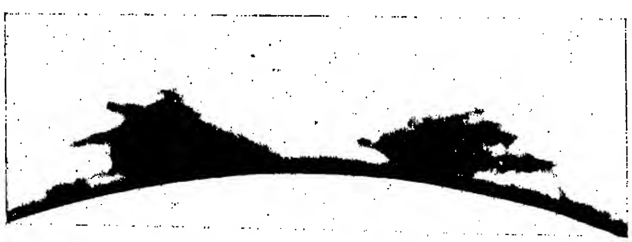

Fig. 5. Ca.

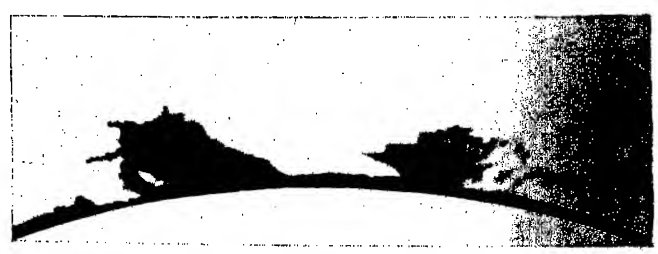

Fig. 5. Hα.

Fig. 6. Ca.

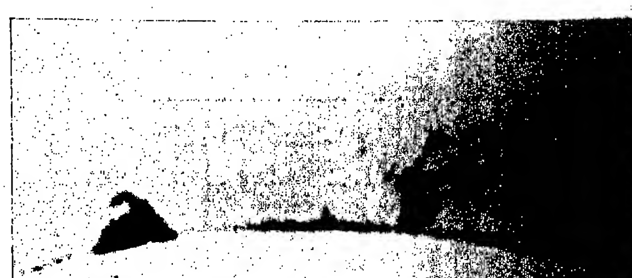

Fig. 6. Hα.

account of the higher gamma value the contrast between the fainter and brighter parts of a prominence in an $H\alpha$ photograph will be greater than in a Ca+photograph. Assuming equal effective exposure in the brightest parts of prominences, it follows that faint details will be lost in $H\alpha$ photographs much sooner than in Ca photographs. Consequently we see that at least part of the explanation of the absence from $H\alpha$ photographs of the faintest parts of prominences lies in the different photographic properties of the plates used. Nevertheless, not all the differences between $H\alpha$ and Ca prominences are due to this, as may be seen especially clearly in figures 7, 8, 9 and 11 where the relative brightness in different parts of the Ca prominences shows that the absence from the $H\alpha$ prominence is not a mere contrast effect.

Effect of Sky Conditions.—It should also be remembered that sky conditions at the time of observation also affect the visibility of the fainter details of prominenc.s. For instrumental reasons the effect of poor skies in extinguishing faint detail is greater in the case of the Kodaikanal K spectroheliograms than for $H\alpha$ spectroheliograms, i.e., the effect is in the opposite direction to that of the characteristic properties of the photographic plates as mentioned in the previous paragraph. In all of the photographs reproduced in plates I and II accompanying this bulletin the sky conditions were at least fairly good so that any effect of this kind may be left out of consideration in comparing these photographs.

Effect of Doppler Displacements on Spectroheliograms.—As is well known, the spectroheliograph, from its nature, cannot give a true picture in the presence of Doppler displacements. This defect is serious in the study undertaken in this bulletin, namely of the true form of prominences. If a part of the prominence is moving in the line of sight to the extent of displacing the line off the second slit of the spectroheliograph, this part of the prominence will be missing in the photograph. Although both the Ca and $H\alpha$ spectroheliograms will be subject to this effect in a similar way, it is not practicable to arrange that the effect will be of exactly the same amount in the two spectroheliographs. The width of the second slit of th: Kodaikanal $H\alpha$ spectroheliograph is $2\times0{\cdot}15$ A, corresponding to a Doppler displacement due to 7 km/sec in either direction whereas in the K instrument the width of the second slit is $2\times0{\cdot}25$ A, corresponding to 20 km/sec in either direction. Although Doppler shifts of these amounts will not suffice to displace the lines completely off the slit on account of the widths of the lines themselves, yet it is clear that Doppler displacements will have a greater effect on the $H\alpha$ spectroheliograms than on the Ca spectroheliograms.

The only way of eliminating the effects of Doppler displacements in prominence photographs is by photographing prominences during a total eclipse with an objective prism. This has been done on many occasions and all the available evidence seems to be that the form and height of prominences is the same in at least the elements Ca^+, H and He. On account of the infrequency of eclipses, the amount of evidence obtained in this way is not great.

Plates I and II.—A few of the prominences photographed in Ca^+ and $H\alpha$ have been chosen for illustration in Plates I and II accompanying this bulletin. An adequate representation of all the types of prominences photographed in three years would require a large number of plates but the examples chosen for reproduction have been selected in order to show not only typical prominences but also some of the extreme cases. Plate I shows chiefly prominences where the resemblance between the Ca and the $H\alpha$ forms is very close. Figure I shows the whole limb of the sun on the 27th February 1929, with the calcium photograph almost indistinguishable from the hydrogen photograph. In Fig. 1 the photographs are reproduced on the same scale as the original. The remaining figures are enlarged 3·9 times. Figs. 2 to 6 illustrate prominences all of the quiescent type, except the one on the right of Fig. 6. With this exception, these prominences are all of the solid massive type, especially in $H\alpha$, and it is seen that the outlines and heights are practically identical in Ca and in $H\alpha$. Figs. 2 and 4, especially, indicate that the $H\alpha$ photographs, are not suffering from underexposure relative to the calcium photographs, for in these the $H\alpha$ prominences are relatively more dense and compact. Types of prominences which occur more frequently than the number chosen for illustration would indicate are shown in figures 7 and 8. Here massive prominences in Ca light show only in skeleton form in $H\alpha$, although there is nothing to suggest underexposure in the latter. Whilst generally it is the strongest parts of the Ca prominence which form the skeleton structure in $H\alpha$, this is not

invariably the case. It would appear that in prominences of this type the ratio of the number of Ca : H atoms is not the same in all portions of the prominence, but conclusive evidence is not available in consequence of the possibility of Doppler displacements, although no radial motion was noted in visual observations in Hα. The differences between Ca prominence and its Hα skeleton would appear to be due to differences of brightness rather than to any essential difference in the forms of the prominence in the two elements. Essential differences in the form of a prominence in Ca and Hα have only been noted in prominences of the type illustrated in Fig. 9, where the arm indicated by the arrow in the Ca prominence, although one of the strongest parts of the prominence, is entirely missing in Hα. Its absence is not due to changing form as it is also present in the Ca photograph taken before the Hα. Presumably this is the type observed by Pettit*, but in Kodaikanal experience clear cases of such phenomena are comparatively rare. Fig. 10 illustrates a prominence, eruptive in parts, in which portions are relatively faint in Hα. Generally in eruptive prominences, the Hα counterpart is relatively fainter than in the cases of massive quiescent prominences and the degree of faintness varies considerably in different cases. Compare Figs. 6, 10, 12, 13 and 14 in this respect. Probably Doppler shifts due to radial motion are responsible for some, at least, of these effects. In Fig. 11 the high streamer is missing in Hα although not so extremely faint in Ca compared to portions which are reproduced in Hα. Figs. 12, 13 and 14 illustrate types of eruptive prominences. Fig. 12 is the jet or fountain type over a sunspot and changes are taking place rapidly in its form. There is, however, nothing to indicate essential differences of form and height in the Hα photographs. In Figs. 13 and 14 the changes are slower and apart from differences of brightness there appears no essential difference in the forms and heights of the Ca and Hα photographs. It would have been easy to multiply examples of eruptive prominences. In cases where rapid motions of ascent are taking place it is easily verified that the Hα form is ascending with the calcium. Even in the case of the remarkable prominence of 1928 November 19† the form is, up to the limits of the plate at 8′ above the sun's surface, identical in Hα light (in the only Hα photograph taken) with the Ca counterpart. Indeed if the H atoms did not partake completely of the same motion as the Ca atoms, there could not be the similarity of form and height as is evidenced in eruptive prominences. For even if the forms were similar in the beginning, a difference in the speed of ascent would soon cause them to cease to bear any resemblance to each other at the same heights above the sun's surface. The mere fact that ascending prominences have essentially the same form and height in Ca and in H would suffice to indicate that the motions of Ca and H must be identical. The essential identity of eruptive prominences in their form, height and motion in Ca and H has a most important bearing on the radiation pressure theory. Perepelkin ‡ finds, on the other hand, that the Doppler displacements of Ca^+ and $H\epsilon$ are not equal, the ratio of radial velocities for Ca^+ : $H\epsilon$ being greater than unity, but these relate to movements in the line of sight which may not be caused in the same way as movements of ascent or descent in the sun.

Fig. 15 is an extreme case of the difference of brightness of Hα in different prominences. The middle prominence is very much fainter in Hα than its brightness in Ca^+ would warrant. As a Doppler displacement amounting to 1·5 A was observed visually in the middle prominence, it is probable that the faintness in Hα is due to this cause.

Selective Radiation Pressure on Ionised Calcium.—Notwithstanding the fact that radiation pressure cannot support the atoms of H and He in the sun's chromosphere, yet it cannot be denied that selective radiation pressure must operate at least on the atoms of Ca^+ in accordance with Milne's theory. Milne has shown § that the amount of pressure of radiation from the sun's photosphere is of the order required to support a Ca^+ chromosphere, any local enhancement of photospheric brightness driving out the Ca^+ atoms to form a prominence. The calculated amount of the radiation pressure has been modified from Milne's original estimate, chiefly by taking more accurate account of the exact amount of energy absorbed in the Ca^+ lines.‖ It has to be pointed out that the energy absorbed by Ca^+ is still incorrectly estimated because the background

* Pettit, loc. cit.
† Royds, M.N., R.A.S., 89, 255—1928.
‡ Perepelkin, loc. cit.
§ Milne, loc. cit.
‖ Minnaert, Z. f. Physik, 45, 610—1927. Unsold, Ap. J. 69, 209—1929. See Menzel, M.N., R.A.S., 91, 628—1931.

of radiation from which the Ca^+ chromosphere is absorbing light is not the continuous spectrum from the photosphere, nor even the continuous spectrum after passing through the layer absorbing the wings of the Ca^+ lines. Taking the K line, it is well known that Ca^+ atoms above the photosphere are so conditioned as to give rise to the portions of the line known as K_1, K_2 and K_3. The K_1 absorption in the wings of the line comes from the deepest layers, the K_2 reversal is caused by conditions in a higher layer not yet satisfactorily explained and the K_3 absorption in the centre of the line is caused by the highest layers. If the sun's chromosphere absorbing K_3 radiation were removed we should not see, in the centre of the K line, either the sun's continuous spectrum from the photosphere, nor this after absorption in the K_1 layer. What we should see would be a bright line whose wings we know as K_{2V} and K_{2R}. How bright would be the centre of the K_2 line we do not know, but presumably it would not be less bright than the observed K_2 wings. Now the K_2 reversals vary enormously in brightness in different parts of the sun. Even over the undisturbed areas of the sun, K_2 is not uniformly bright as the Ca spectroheliograms show. The normal brighter and darker network in these photographs possibly appears with greater contrast than the actual variations of brightness of the K_2 line in quiescent regions of the sun. There is, however, no observation to suggest that the height of the chromosphere at the limb varies in a corresponding manner, a fact which is possibly due to the foreshortening of the close network at the limb of the sun. Besides this normal variation of the K_2 line in undisturbed regions of the sun, the K_2 line is very much brighter over disturbed areas of the sun, giving rise to the calcium flocculi. Indeed K_2 can be very much brighter than the undimmed continuous spectrum from the photosphere. So we see that the K_3 absorbing layer can be subject to radiation pressure which may vary between very wide limits over different parts of the sun. If the normal brightness of K_2 is just sufficient to support the chromosphere against gravitation, the brightest states must force the Ca^+ atoms above it completely away from the sun. Exact estimates must await photometric measures.

If the radiation supporting Ca^+ atoms comes from the K_2 layer as mentioned above, there will also be a further effect when the prominence ascends. As explained by Milne, an ascending prominence will absorb light from the wings of the Ca line owing to Doppler displacement of the absorption line. Owing to the K_2 reversals, however, the prominence will be subject to a decreasing radiation pressure as the absorption moves off the K_{2V} line. In undisturbed regions of the sun this minimum radiation is at about 0·26 A on the violet side of the centre of the line, corresponding to a velocity of ascent of about 20 km/sec, but in disturbed regions the minimum radiation will be only reached by greater velocities. Should this critical velocity be overshot, then the ascending prominence will be subject to an ever-increasing radiation pressure, as originally conceived by Milne, until the absorption is displaced beyond the K_1 wing.

Conclusions.—1. The comparison of photographs of prominences taken in calcium and in hydrogen light shows that the forms of quiescent prominences are essentially the same in these two elements, even to considerable detail. This is in agreement with the conclusions of other observers. Since radiation pressure can only exert an appreciable force on the atoms of Ca^+ and not on atoms of H, this evidence is not in favour of the theory of radiation pressure as the force supporting prominences.

2. Even in the case of eruptive prominences where the relative brightness in $H\alpha$ is generally less than in other types, the essential similarity of form and of height attained is maintained and the motion of ascent of Ca^+ atoms is also partaken of by the atoms of H. This evidence is also not in favour of the theory of radiation pressure as the propelling force in eruptive prominences.

3. The relative brightness of the calcium K line and of the $H\alpha$ line may vary in different prominences and even in different parts of the same prominence. Owing to the possible effects of Doppler displacements spectroheliograms cannot offer conclusive evidence as to whether these variations in brightness are really due to varying proportions of the numbers of Ca^+ and of H atoms.

4. Consequent on the conclusions 1 and 2 above it seems quite clear that whatever force raises Ca^+ atoms into prominences, and sometimes drives them away from the sun, is also acting, either directly or indirectly on hydrogen atoms also (and presumably on helium atoms as well). That radiation pressure on

Ca^+ atom is appreciable cannot be denied. Whether it is possible for Ca^+ atoms to be raised by radiation pressure into prominences and for other atoms to be carried along with Ca^+ atoms, by collisions or in some other way, is a subject for investigation, but if radiation pressure on Ca^+ atoms is the ultimate force lifting H and He atoms also, the weight to be supported by radiation pressure must take account of these atoms as well as those of calcium. It would not be of much help to find a new cause for supporting H and He different from that supporting Ca^+, since it is unlikely that any such effect would be just sufficient to support H and He to exactly the same height as radiation pressure does Ca^+.

5. It is shown that calculations of the radiation pressure on Ca^+ atoms must take account of the radiation in the reversals of the Ca^+ lines, but the effect cannot be exactly calculated until photometric measures are available.

KODAIKANAL,
21*st March* 1932.

T. ROYDS,
Director, Kodaikanal and Madras Observatories.

PARTICULARS OF THE REPRODUCTIONS IN PLATES I AND II.

All the photographs are positives. Figure 1 is reproduced on the same scale as the original and figures 2 to 15 are 3·9 times enlargements. One inch in figures 2 to 15 represents 3·5 minutes of arc, or 95,000 miles, or 152,000 km. The times given below are the times of transit of the centre of sun's disc and are in Indian Standard Time, (5½ hours fast on G.M.T.).

—	Date.	Extent.	Ca photograph taken at H.	M.	H photograph taken at H.	M.
Fig. 1	1929, Feb. 27.	Entire limb.	8	0	8	28
Fig. 2	1930, Apr. 9.	13°SW to 35°SW.	8	34	8	25
Fig. 3	1929, Dec. 10.	40°SW to 57°SW.	8	56	8	41
Fig. 4	1930, June 11.	10°NE to 35° NE.	8	18	8	41
Fig. 5	1930, Apr. 23.	35°SE to 10°NE.	8	17	8	2
Fig. 6	1929, Sep. 12.	15°SW to 60°SW.	8	20	8	10
Fig. 7	1931, Feb. 7	15°SE to 27°NE	8	45	8	26
Fig. 8	1930, May 4	22°SE to 80°NE.	8	4	8	29
Fig. 9	1930, Feb. 5.	5°SW to 30°SW.	8	52	8	42
Fig. 10	1928, Dec. 15.	15°NW to 20°SW.	9	13	8	48
Fig. 11	1930, Feb. 6	18°SW to 43°SW.	7	54	8	12
Fig. 12	1929, Dec. 10.	7°SE to 15°NE.	8	56	8	41
Fig. 13	1929, Dec. 10.	5°NW to 20°SW.	8	56	8	41
Fig. 14	1929, Jan. 14.	10°NE to 35°NE.	8	45	8	29
Fig. 15	1930, June 24.	35°NW to 23°SW.	11	31	11	47

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Kodaikanal Observatory.

BULLETIN No. XCVI.

THE VARIATION IN AREA OF HYDROGEN ABSORPTION MARKINGS WITH LONGITUDE

BY

M. SALARUDDIN, B.A.

Abstract.—The results in this paper are based upon the Hα spectroheliograms taken at Kodaikanal Observatory during the years 1926—1930.

The areas of the Hα absorption markings lying longitudinally on the surface of the sun were measured and compared with those of the respective ones at the central meridian. The areas were found to be least at the central meridian increasing with longitude towards the limb. The ratio of the area of a marking at any longitude λ to its area at the central meridian is found to fit the formula $\cos\lambda + \left(\frac{h}{b}\sin\lambda - \frac{\cos\lambda}{2}\right)$ where b is the breadth and h the height of the marking above the chromosphere. The factor $\frac{h}{b}$ was found to be about 1·8 for markings at all latitudes and 1·9 for the equatorial ones alone.

The breadths of the Hα dark markings at the central meridian were measured for the two years 1926 and 1930. The mean breadth was found to be 17″·3 for markings at all latitudes and 15″·4 for the equatorial markings alone. The respective heights deduced were 31″·1 and 29″·2.

Introduction.—The areas of Hα dark markings were originally regarded to behave in the same way as sunspot areas, varying as the cosine of their angular distances from the centre of the sun's disc, due to the curvature of the sun's surface. It was under this assumption that the measured areas of the Hα dark markings were corrected for foreshortening, before incorporating the results in the Kodaikanal Observatory Bulletins. This practice is still continued though it has long been known that the areas do not vary according to this law. This can be seen from the accompanying plate where a longitudinal Hα marking is followed from the eastern limb of the sun to the western, and it is quite evident that the area near the limb is actually larger than that near the central meridian. Since the areas of dark markings do not actually vary according to the foreshortening factor, the uncorrected areas have been given in Kodaikanal Observatory Bulletin No. XC and onwards, the areas corrected for foreshortening being continued for the purpose of comparison with the previous bulletins.

To find out some empirical law according to which the areas of Hα markings vary with longitude, a detailed study of a number of markings is required, and on the suggestion of Dr. T. Royds the present work was undertaken.

Method and Results.—The Hα dark markings selected for the purpose of this investigation were those that lay longitudinally or only slightly inclined to a meridian of the sun and that also persisted at least for a quarter rotation of the sun on the visible hemisphere. If a marking extended through more than 5° of latitude, the portion of the marking in each belt of 5° of latitude was treated as an individual marking. The areas of the markings were measured on successive days on which the Hα spectroheliograms were available

and tabulated according to their observed longitudes from the central meridian in columns of 5 each The ratios of these areas to those of the respective markings at the central meridian were calculated For this purpose the mean area of a marking between 15 east and 15 west of the central meridian was taken to be its area at the central meridian The same procedure was adopted for all the available markings during the years 1926—1930

These results are shown in table I below The ratios for east and west are shown separately for each year together with their means The numbers within brackets indicate the number of markings measured in each zone of longitude

TABLE I

Mean Ratios for all Latitudes

Longitudes	15—20	20—25	25—30	30—35	35—40°	40—45	45—50	50—55	55—60	60—65	65—70°	70°—75	75°—80°	80°—85°
							1926							
E	0 98	1 03	1 15	0 95	0 96	1 36	1 03	1 63	1 18	1 20	1 94	2 08	0 70	[illegible]
	(26)	(18)	(31)	(21)	(14)	(32)	(18)	(23)	(23)	(15)	(17)	(10)	(6)	
W	1 35	1 28	1 58	1 62	1 54	1 95	1 99	1 93	2 15	2 70	2 09	2 50	2 29	[illegible]
	(18)	(28)	(28)	(28)	(17)	(21)	(25)	(16)	(13)	(22)	(7)	(2)	(1)	
Mean.	1 16	1 12	1 36	1 29	1 25	1 65	1 51	1 78	1 64	1 85	2 01	2 29	1 50	[illegible]
							1927							
E	1 09	1 40	1 15	1 40	1 58	1 19	1 81	1 76	1 14	1 72	1 73	1 47	1 05	[illegible]
	(33)	(35)	(27)	(22)	(44)	(31)	(32)	(30)	(22)	(13)	(29)	(22)	(6)	[illegible]
W	1 23	1 26	1 45	1 64	1 78	1 48	1 56	2 13	2 18	2 22	2 37	1 74	2 56	[illegible]
	(21)	(1)	(18)	(20)	(17)	(26)	(14)	(17)	(24)	(15)	(11)	(15)	(4)	[illegible]
Mean.	1 16	1 33	1 30	1 52	1 68	1 34	1 69	1 94	1 66	1 97	2 05	1 61	1 81	[illegible]
							1928							
E	1 24	0 84	1 16	1 18	1 12	1 60	1 47	1 21	1 88	1 23	2 10	1 99	1 66	[illegible]
	(36)	(28)	(39)	(27)	(28)	(28)	(28)	(21)	(38)	(23)	(16)	(23)	(12)	[illegible]
W	1 16	1 38	1 26	1 21	1 49	1 22	1 30	2 02	1 54	1 68	2 01	1 88	1 56	[illegible]
	(27)	(35)	(31)	(25)	(36)	(26)	(22)	(27)	(20)	(22)	(26)	(16)	(11)	[illegible]
Mean	1 20	1 11	1·21	1 20	1 30	1 41	1 39	1 61	1 71	1 46	2 05	1 94	1 60	[illegible]
							1929							
E	0 99	1 07	0 65	1 22	1 10	1 30	1 27	1 06	1 32	1 27	0 83	1 09	0 94	[illegible]
	(23)	(15)	(11)	(6)	(9)	(18)	(13)	(11)	(13)	(8)	(7)	(9)	(7)	[illegible]
W	1 06	1 51	1 41	1 51	1 39	1 52	1 63	1 45	2 09	2 21	2 02	1 95	1 58	[illegible]
	(16)	(16)	(23)	(22)	(18)	(19)	(22)	(15)	(15)	(16)	(6)	(6)	(12)	[illegible]
Mean	1 03	1·29	1 03	1 36	1 25	1 41	1 45	1 26	1 70	1·74	1 43	1 52	1 26	[illegible]
							1930							
E	1·21	0 80	1 93	1 50	1 44	1·63	1 40	1 86	1 77	1 88	2 02	1 05	1 59	[illegible]
	(16)	(10)	(12)	(15)	(7)	(9)	(15)	(4)	(10)	(7)	(3)	(2)	(4)	[illegible]
W	1 43	1 59	2 14	1 46	1 70	2 28	2 04	2 27	1 87	2 89	1 86	2 09	1 38	[illegible]
	(14)	(16)	(7)	(10)	(15)	(13)	(12)	(7)	(12)	(5)	(5)	(5)	(1)	[illegible]
Mean.	1 32	1 20	2 03	1 48	1 57	1 95	1 72	1 81	1 82	2 38	1 94	1·57	1 48	[illegible]
							1926 to 1930							
E	1·10	1 09	1·19	1 26	1 32	1 38	1 46	1 49	1 48	1 39	1 79	1 68	1 24	[illegible]
	(134)	(106)	(120)	(101)	(102)	(118)	(106)	(89)	(106)	(66)	(72)	(66)	(34)	[illegible]
W	1 23	1 38	1 46	1·49	1 56	1 61	1 69	1 94	1 96	2 24	2·08	1·69	1 72	[illegible]
	(96)	(116)	(107)	(105)	(103)	(105)	(95)	(82)	(84)	(80)	(55)	(44)	(29)	[illegible]
Mean	1 16	1 23	1 32	1 38	1 44	1 50	1 58	1 72	1 72	1 82	1 93	1·79	1 48	[illegible]

The numbers of markings measured in different latitudes are given in table II. These include markings both north and south of the equator It will be seen from the table that not many markings are available beyond latitude 40 and none beyond 50 as the markings at higher latitudes are almost parallel to the equator

TABLE II.

Number of Markings measured in each Belt of Latitude.

Year.		0°—5°.	5°—10°.	10°—15°.	15°—20°.	20°—25°.	25°—30°.	30°—35°.	35°—40°.	40°—45°.	45°—50°.	Total.
1926 ...	...	6	5	6	16	21	17	9	3	..	...	83
1927 ...	...	7	10	14	21	15	13	15	9	...	...	104
1928 ...	...	8	12	18	25	21	12	11	4	1	1	113
1929 ..	...	8	7	13	13	13	7	8	2	1	...	72
1930 ...	...	8	7	10	5	5	5	2	...	...	...	42
1926—30	...	37	41	61	80	75	54	45	18	2	1	414

It was desired to know whether the equatorial markings differ in any way from those at higher latitudes in their behaviour with regard to area. For this purpose the markings lying between 15° north and south of the equator were sorted out and their ratios calculated as before. The results are given in the following table :—

TABLE III.

Mean Ratios for Latitudes $+15°$ *to* $-15°$ *only.*

1926—30.

Longitudes.	15°—20°.	20°—25°.	25°—30°.	30°—35°.	35°—40°.	40°—45°.	45°—50°.	50°—55°.	55°—60°.	60°—65°.	65°—70°.	70°—75°.	75°—80°.	80°—90°.
E ...	1·17	1·09	1·28	1·34	1·64	1·49	1·52	1·93	1·55	1·72	2·04	1·67	1 66	1·13
	(41)	(32)	(37)	(40)	(31)	(38)	(35)	(26)	(34)	(21)	(23)	(21)	(11)	(3)
W ...	1·22	1·36	1·41	1·47	1·36	1·72	1·93	1·79	2·19	2·32	2·19	2·11	1·94	1·39
	(30)	(35)	(28)	(35)	(33)	(34)	(29)	(27)	(28)	(27)	(19)	(14)	(14)	(4)
Mean.	1·19	1·23	1·35	1·41	1·50	1·60	1·72	1·86	1·87	2·02	2·11	1·89	1·80	1·26

The results in tables I and II are represented graphically in diagrams 1 and 2, the ordinates representing the mean ratios for the years 1926—1930 and the abscissæ the mean longitudes from the central meridian. These longitudes are the observed longitudes which are slightly higher than the real longitudes on account of the height of the markings above the chromosphere. But the difference between the measured and the true longitudes is small being only about 0°·5 at 45° longitude, and about 1° at 60° longitude, assuming the base and height of the marking to be on the average 15″ and 30″ respectively. Therefore, this difference was not taken into account in measuring the longitudes of the markings. Moreover, as the markings were grouped together in zones of 5° of longitude and as the mean longitude of each zone was taken to represent the mean longitude of all the markings in that zone, the majority of the markings would not be affected. Only a few of the markings would fall into the next lower zones. The effect of this would be to just shift the curves given below towards the left without seriously distorting their shapes.

Diagram 1.—Mean Ratios for Markings at all Latitudes

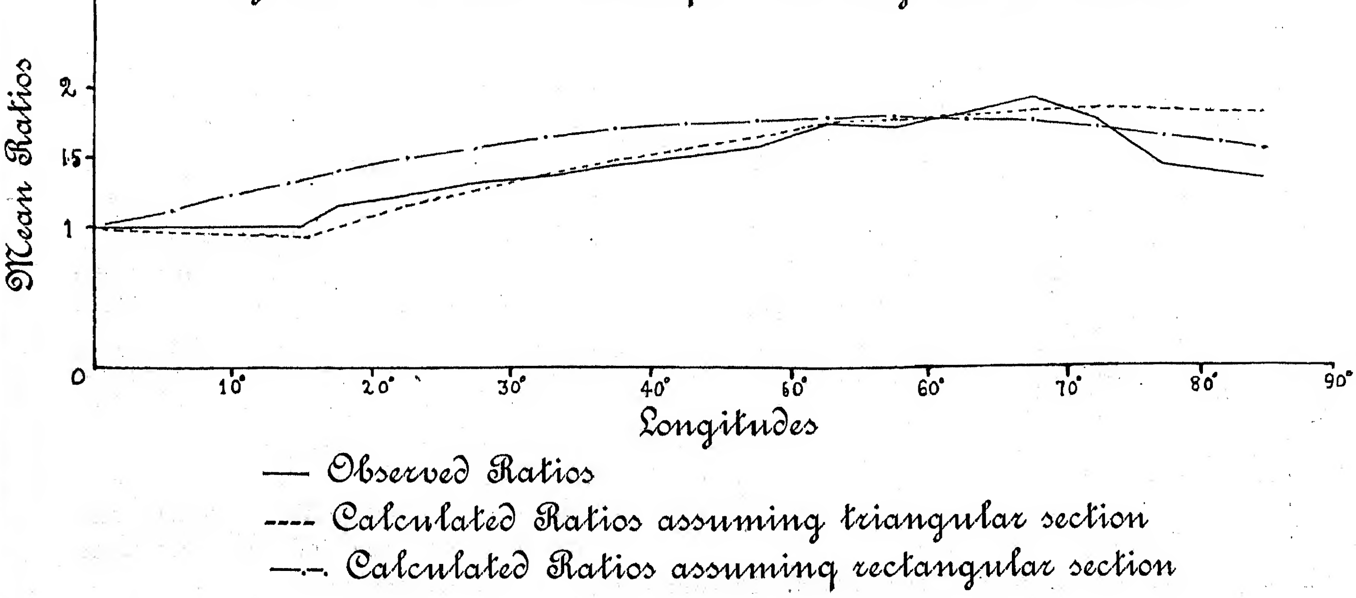
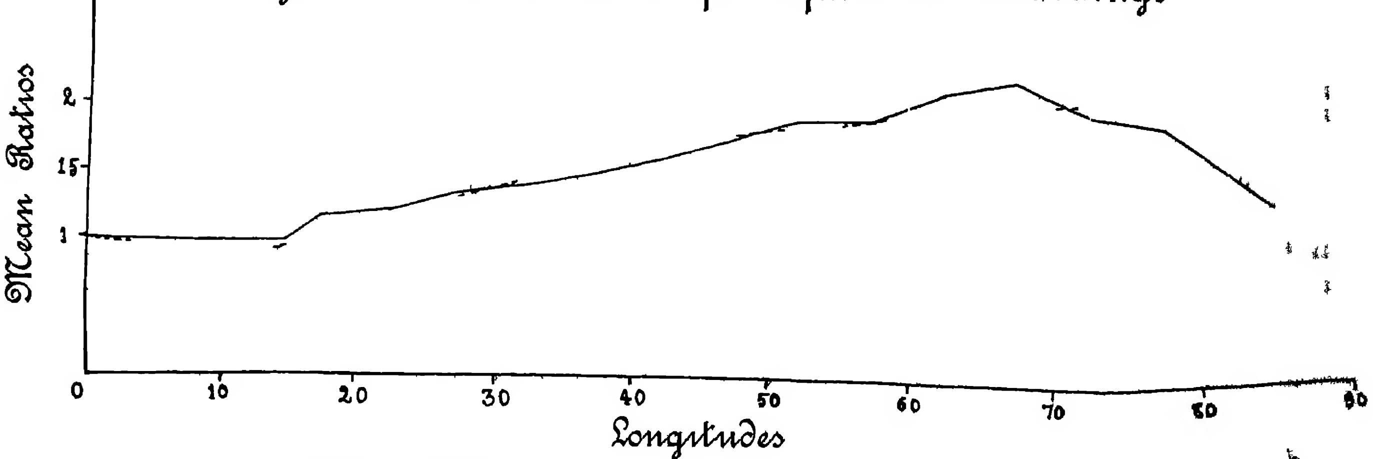


Diagram 2—Mean Ratios for Equatorial Markings

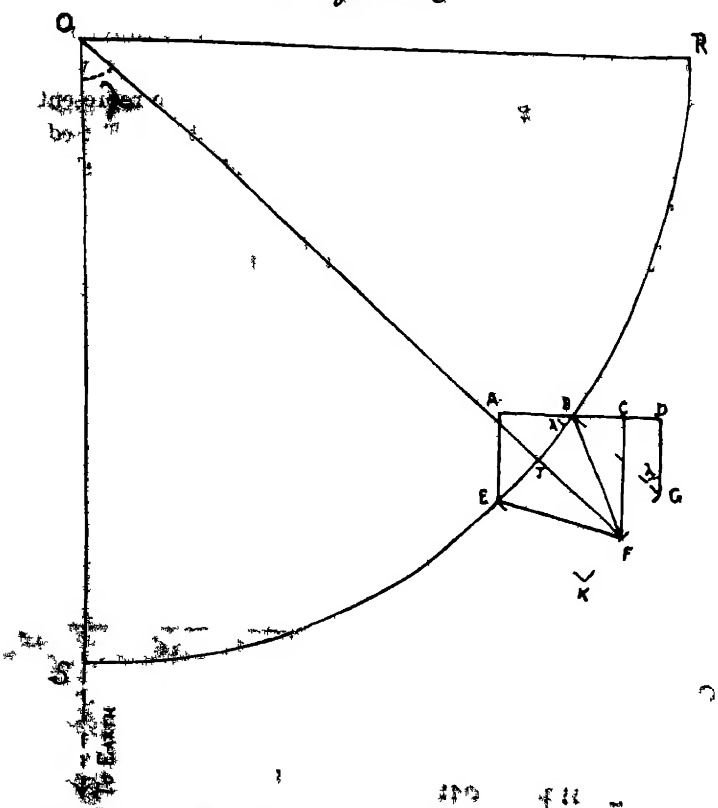


— Observed Ratios
Calculated Ratios assuming triangular section

The full line curves in the diagrams represent the observed ratios It will be seen that both the curves are similar in general shape excepting that the ordinates in diagram 2 are slightly higher than those of diagram 1 In both the curves the ratios increase from unity at the central meridian to about 2 at longitude 70 Beyond this they begin to decrease but it is doubtful whether this decrease is real on account of the difficulty of making reliable measures on markings near the limb

Conclusions—It should now be considered why an Hα absorption marking should present the least area when at the central meridian and why it should increase with longitude. If we conceive of it as a flat area carried around the surface of the sun from the central meridian it should appear to decrease according to the cosine of its longitude as it moves towards the limb It is only under the assumption that the Hα areas as given in the Kodaikanal Observatory Bulletins were corrected for foreshortening But this does not correspond with the facts An Hα marking is not a flat area carried around the surface of the sun It should be regarded as a huge mass of hydrogen gas rising above the chromosphere to a certain height It is probably the hydrogen prominence itself projected on the disc When an equatorial marking is at the central meridian we look directly at it and what we see is its full base the height of the marking not interfering But at any other longitude we see only its foreshortened base together with the projection of its height This projected area due to the height of the marking would increase towards the limb according to the sine of its longitude from the central meridian This can be clearly seen from diagram 3

Diagram 3

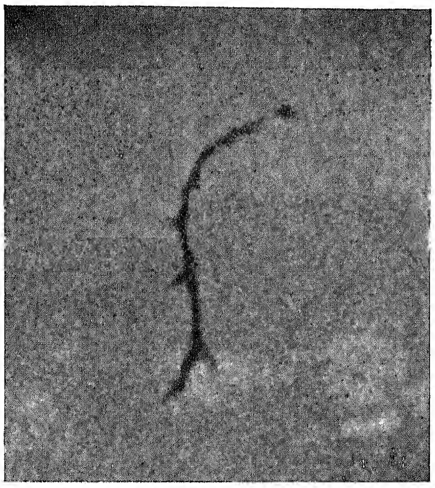


1927 March 18, 2^{h} 28^{m} G. C. T.
Mean longitude 58° E.

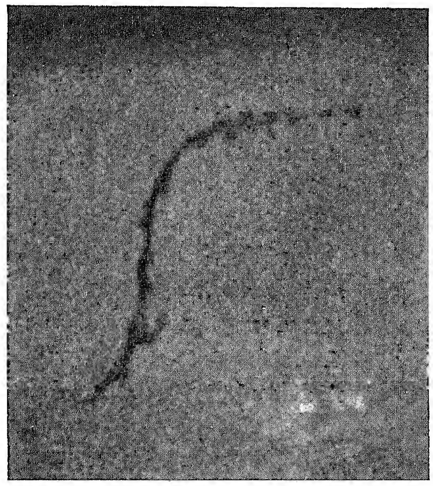
1927 March 19, 2^{h} 42^{m} G. C. T.
Mean longitude 45°E.

1927 March 20, 2^{h} 35^{m} G. C. T.
Mean longitude 32° E.

1927 March 21, 3^{h} 24^{m} G. C. T.
Mean longitude 18°E.

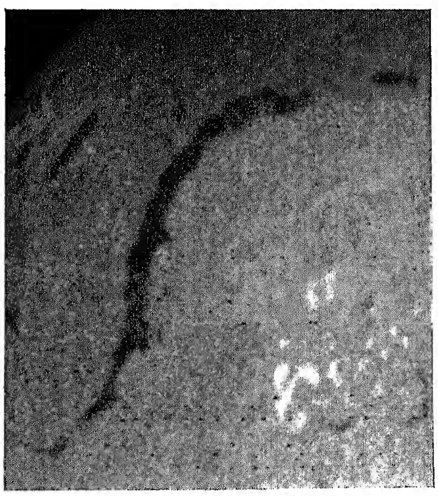


1927 March 22, 2^{h} 27^{m} G. C. T.
Mean longitude 5°E.



1927 March 23, 2^{h} 49^{m} G. C. T.
Mean longitude 8°W.

1927 March 24, 2^{h} 32^{m} G. C. T.
Mean longitude 22°W.



1927 March 25, 3^{h} 10^{m} G. C. T.
Mean longitude 36°W.

1927 March 26, 2^{h} 26^{m} G. C. T.
Mean longitude 50°W.

The marking lies between latitudes 7° N and 34° N. All the photographs are positives on a scale of 204 mm to the diameter of the Sun.

Before proceeding to devise the exact nature of the change in the area of the marking with longitude, some assumption regarding its cross-section is necessary. In the diagram, O R S represents the equatorial plane in the sun, O, R and S being the points on the axis, east limb and the central meridian respectively. Consider a longitudinal Hα marking at an angle λ from the central meridian. Assuming the cross-section to be a rectangle, let E B G K in the figure represent a section of the marking at right angles to its length. Let its breadth E B be equal to b, and its height J F be equal to h.

Neglecting the effect of the inclination of the sun's equator to the ecliptic which is small, an observer from the earth always looks at the sun in a direction parallel to S O. He will not notice any appreciable change in the length of the marking, but to him A D will appear to be the breadth of the marking. But $AD = AB + BD = b\cos\lambda + h\sin\lambda$.

On this assumption the ratio of the area of any marking at longitude λ to its area at the central meridian will be $\cos\lambda + \frac{h}{b}\sin\lambda$. In diagram 1 the curve with alternate dashes and dots was drawn with the values calculated from this formula, assuming for $\frac{h}{b}$ the value 1·5. It is evident that it cannot be made to fit the actual curve on account of the too rapid increase in ratios near the central meridian.

It is therefore necessary to discard the assumption of a rectangular cross-section for the marking, and to assume a triangular cross-section instead, an assumption which is justified by the general shape of the prominences on the limb giving rise to the Hα dark markings. In the figure E B F represents a triangular cross-section of base b and height h. A C will now appear as the breadth of the marking when seen from the earth.

$$AC = AB + (BD - CD)$$
$$= b\cos\lambda + \left(h\sin\lambda - \frac{b}{2}\cos\lambda\right)$$

The length of the marking remaining the same, the ratio of its area at longitude λ to its area at the central meridian will be $\cos\lambda + \left(\frac{h}{b}\sin\lambda - \frac{1}{2}\cos\lambda\right)$.

This is true only if C falls outside A B. For small values of λ, C falls inside A B and the breadth of the marking will be only A B, so that the ratio will be represented now by $\cos\lambda$ alone.

As we have seen, this formula is derived taking into account a marking near the equator. It can be also shown that whatever be the latitude of the marking, the ratio of its area at longitude λ to its area at the central meridian remains the same to a close approximation. Moreover all the markings measured are between $\pm 40°$ of latitude.

Now if the above formula were taken to be correct, we expect hat the ratios got by measurement should compare well with the ratios calculated from the formula, the constant $\frac{h}{b}$ being properly chosen. In the diagrams 1 and 2 the broken line curves were drawn with the ratios calculated from the formula as ordinates, taking the constant to be 1·8 and 1·9 respectively. We see that these curves agree fairly well with the full line curves drawn with the observed ratios as ordinates, except near the limb where close agreement cannot be expected on account of the difficulty of obtaining reliable measures.

The fact that very few markings remain quiescent for a long time and that many of them will be undergoing sudden changes with respect to their base and height should not be also forgotten. But it is hoped that in the mean ratios for the five years given in the last row of table I, this error is greatly minimised. Besides as these are the means of ratios measured in the corresponding zones east and west of the central meridian, any abnormal change in the eastern zone may be supposed to have been compensated by a reverse change in the corresponding western zone and vice versa. This is what we notice by a comparison of the ratios east and west of the central meridian. The western ratios are slightly higher than the eastern ones. This is probably due to the fact that most of the markings measured to the west were growing ones.

Heights of the Ha Absorption Markings.

The formula derived in this paper not only explains the observed variation in the area of H*a* markings with longitude, but it also gives the relation between the height and the breadth of the marking. It shows that the mean height of a marking is about 1·8 times its apparent breadth near the central meridian. For the equatorial markings, this ratio is slightly higher, viz., 1·9. Therefore, if the mean breadth of a marking near the central meridian is known, its height can be deduced. For this purpose, the breadths of 116 markings for the two years 1926 and 1930 were measured by means of a micrometer. Of these markings only 38 were within 15° north and south of the equator. Care was taken to measure the breadths only when the markings were at or near the central meridian. In each case the mean of at least two or three readings was adopted as the mean breadth. The mean breadth was found to be 0·54 mm. or 17″·3 for markings at all latitudes and 0·48 mm. or 15″·4 for markings within ± 15° of latitude. The heights deduced from these values were 31″·1 and 29″·2 respectively.

These heights correspond with the absolute heights deduced in Kodaikanal Observatory Bulletin No. LXXXIX by quite a different method. According to the arguments given there, it might have been expected here to get only about 5″ for the height of a marking, the lower portion of the marking to a height of about 28″ not showing itself by absorption. It now appears from this paper that that is not the case with all markings.

In conclusion I wish to express my gratitude to Dr. T. Royds and Dr. A. L. Narayan for their valuable guidance and many suggestions.

KODAIKANAL,
19*th April* 1932.

MD. SALARUDDIN.

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Kodaikanal Observatory.

BULLETIN No. XCVII.

TWO LONGITUDINAL ZONES OF APPARENT INHIBITION OF SUNSPOTS ON THE SOLAR DISC

BY

P. R. CHIDAMBARA AYYAR, B.A., F.R.A.S.

Abstract.—Observations of sunspots made at Kodaikanal during the years 1909 to 1929 have been utilized to study the occurrence of spots in different longitudes over the sun. It is found that there is a zone of apparent inhibition between longitudes 30° and 50° on either side of the central meridian. Spots of short duration tend to avoid the zones, while the long-lived ones show a diminution in areas when passing through them.

Although observations of sunspots at Kodaikanal began in the year 1903, a new system of registering the observations was introduced in 1909, giving the serial number of each sunspot, or group of spots as the case may be, its heliographic latitude and longitude, the dates from and to which it was visible on the sun and the longitude, east or west of the sun's central meridian, where it was when first observed. At the end of 1929 there was a mass of material accumulated during 21 years and available in a convenient form. The nature of the distribution of sunspots in latitude was well-known, but no examination of their distribution in longitude had been made by anyone. Although, under ordinary circumstances, no peculiarity could be expected to exist in such distribution, as spots have an equal chance to occur in all longitudes on a rotating globe like the sun, it appeared desirable that the matter should be placed beyond doubt by venturing an actual investigation. Accordingly the Kodaikanal data were made use of for the purpose and the results are set forth in this paper.

Distribution of 1-day Spots.

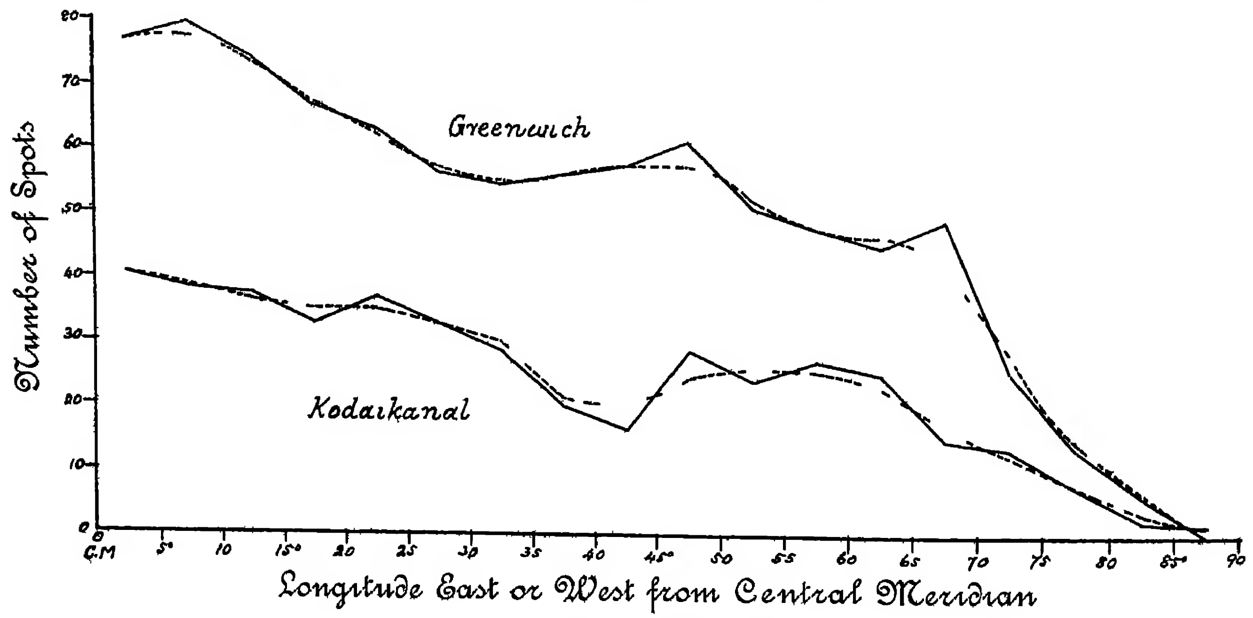
2. The investigation began first with spots of the shortest duration, namely those which were seen on single days only and disappeared before the next day's observation. The second and third columns in the Kodaikanal spot register are headed "Latitude N." and "Latitude S." and the last column "Longitude from Central Meridian when First Seen." The positions of 1-day spots as defined by the register were plotted on squared paper in their proper longitudes and latitudes east and west of a central vertical line representing the central meridian and north and south of a central horizontal line representing the equator, of the sun. There were 857 spots of this class. As the plotting progressed, a remarkable and hitherto unsuspected feature began to manifest itself on the chart. The spots showed a distinct tendency to fall in three separate regions and tended to avoid two longitudinal zones, one on either side of and some distance away from the central meridian. The chart finally showed three concentrations of spot positions, one at the middle of the disc and one at either end, with an attenuation in the region between 30° and 50° of longitude east and west of the central meridian. The number of spots falling inside each zone of 5° of longitude were then totalled up and a curve drawn to represent the arrangement of these totals in the different zones. It was found that the curve rose to a maximum in the region of the central meridian, fell off from 30° reaching a minimum in the zone 35° to 40° in the eastern hemisphere and 40° to 45° in the western hemisphere, and then rose to a secondary maximum near 60° and fell off again.

3. At the suggestion of Dr. Royds, the Director, the data published in the "Greenwich Photoheliographic Results" were also examined for a similar effect for all the past years as far back as the data would carry us. There was material available for 39 years from 1874 to 1912 and there were 1,767 spots seen only on one day. The data regarding the spots are arranged in the form of "Ledgers", which give information regarding each

individual group for each day of observation, the latitudes and longitudes being given to a tenth of a degree From the ledgers the positions of 1-day spots were plotted in the same way as was done for the Kodaikanal data, and a curve drawn to represent the totals in each zone of 5° as before The same phenomenon, as was revealed by the Kodaikanal material, was seen in this case also There was, however, a slight difference in that the two zones of minimum concentration were located about 5° nearer the central meridian All the same, there was no longer any doubt as to the reality of the existence of the two zones of inhibition and three distinct regions of activity on the solar surface As far as 1 day spots are concerned the central region on the solar disc appears to be the most active and the two regions on either side, beyond the gaps of inhibition, comparatively weaker

4 The numbers east and west of the central meridian are combined and means derived The upper curve in diagram 1 shows the means so derived for the Greenwich data and the lower curve shows the same for Kodaikanal The broken lines are the smoothed curves for the two classes of data They show to better advantage the existence of the zones of comparatively smaller activity between 30° and 50° of longitude in both the eastern and western hemispheres

Diagram 1 —Distribution of 1-day Spots in Longitude (Mean of East and West)



Distribution of 2-day Spots

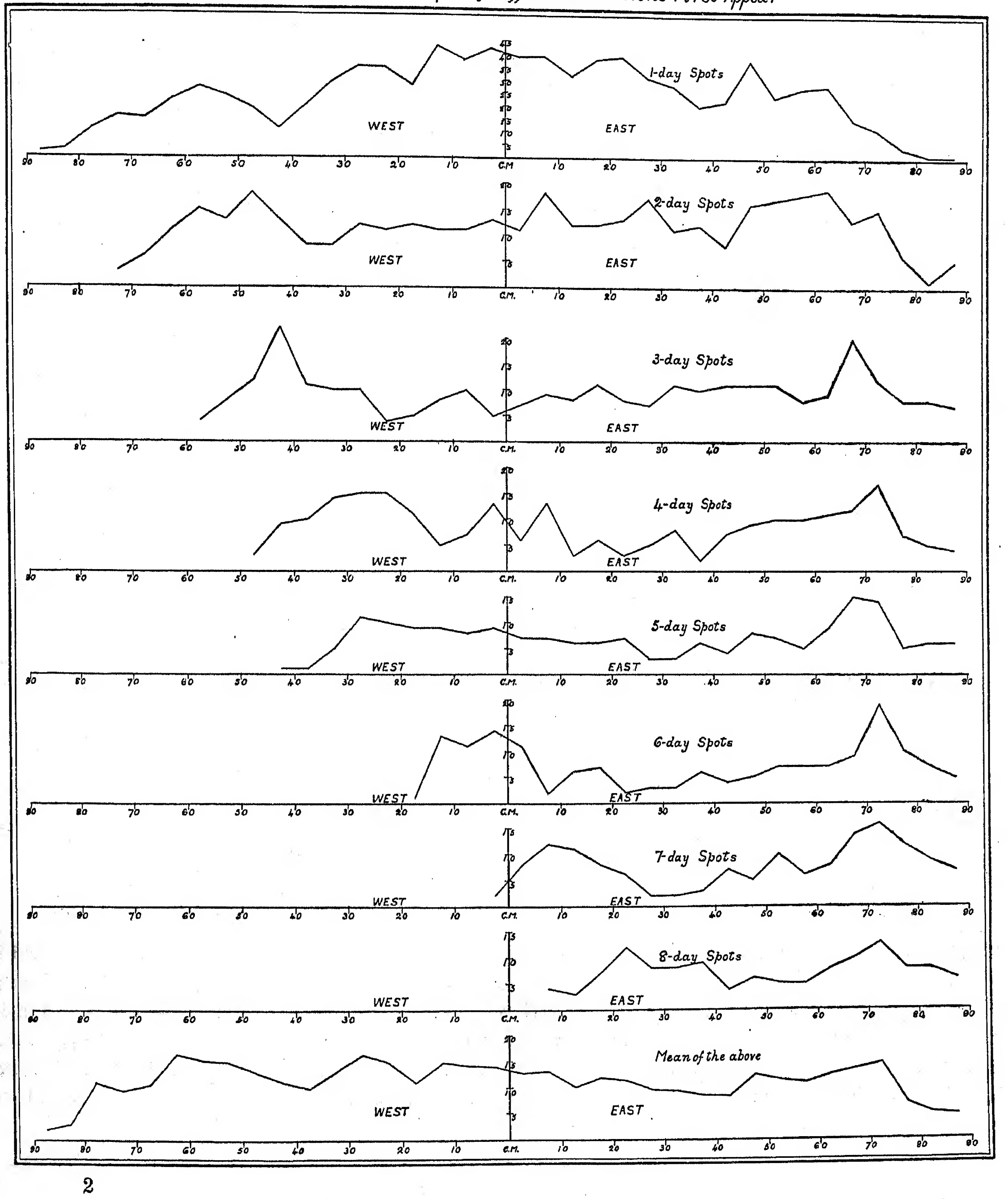
5 The interesting results obtained in the case of 1-day spots naturally led to the question whether the same kind of inhibition could also be observed in the case of spots of greater duration The case of 2 day spots was therefore taken up Spots of greater and greater duration naturally made the problem less and less simple, and from the data furnished by the Kodaikanal register, only the first appearances of each class of spots could be studied. As the sun's disc is daily examined for spots, any new spots observed on a particular day must have come into being some time between that day's and the previous day's observations Of course, the spots that are first seen on the east limb of the sun may all, or most of them, come round from the other side of the sun. Barring these, all other spots must have had their origin somewhere near and to the east of the longitudes at which they were first noticed An examination of these longitudes, therefore, should give us an indication as to the places of origin of the spots On plotting the first appearances (i e, the longitudes when first seen) of 2 day spots, 389 in number, in the same way as the 1-day spots were treated, it was found that the number of first appearances was a minimum in the zones of inhibition revealed by the 1-day spots, but the central concentration became less conspicuous than the two lateral ones

Other Classes of Spots.

6. The same examination was extended to spots of greater duration, but it appeared unnecessary to plot the first appearances in their actual positions in latitude and longitude, as in the previous cases. So columns were opened representing each 5° zone of longitude and the first appearances of each class from 3-day spots to 8-day spots were separately entered in the respective zones in which they fell according to the longitude given by the register. The total numbers of each class of spots were, 270, 240, 187, 159, 148 and 124 respectively. The number of each class in individual zones were then totalled up. The distribution of each class is represented by a curve in diagram 2, along with the curves for 1-day and 2-day spots.

Diagram 2.

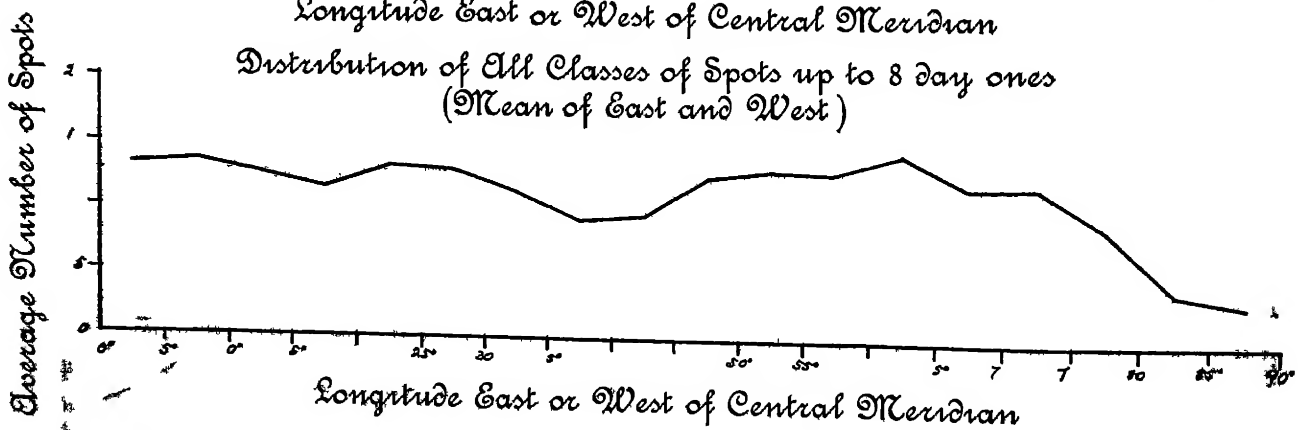
Longitudes in which Sun-spots of Different Durations First Appear



The picture presented by the curves is very interesting Excepting in the case of 1 day spots the central concentration occupies a subordinate position and the two lateral concentrations become the stronger Besides while the peak on the east is more or less permanent in position that on the west shifts more and more eastwards according to the duration of the spot so much so that the western peak in the curve of 4 day spots is found over the region of inhibition in the west and the western peak in the curve of 8 day spots lies over the inhibition zone in the east This no doubt militates against the idea of two permanent zones of comparative inactivity on the solar surface but we have to remember that these spots represented by the peaks in the west are those of which we had two three four five etc observations according to the class to which they belonged and that the last observations of them were near the west limb of the sun Hence we cannot say whether they die out at the limb or disappear from view on the invisible hemisphere They must therefore be considered as spots having a duration longer than two days three days or four days etc as the case may be The peaks have therefore to be regarded as spurious to some extent as the number of real 2 day 3 day 4 day etc spots must be much smaller there But in spite of the exceptional behaviour of the 4 day and 8 day spots the totals as well as the means of all the columns unmistakably record a fall in the regions where the two zones are expected to be as can be seen from the curve at the bottom of diagram 2 The means for east and west for 2 day spots and for the average of all the classes up to the 8 day ones are shown by the two curves in diagram 3 The troughs in the two curves at the seat of the zones is quite evident

Diagram 3 —Distribution of 2-day Spots in Longitude
(Mean of East and West)

Distribution of All Classes of Spots up to 8 day ones
(Mean of East and West)



Areas of Sunspots

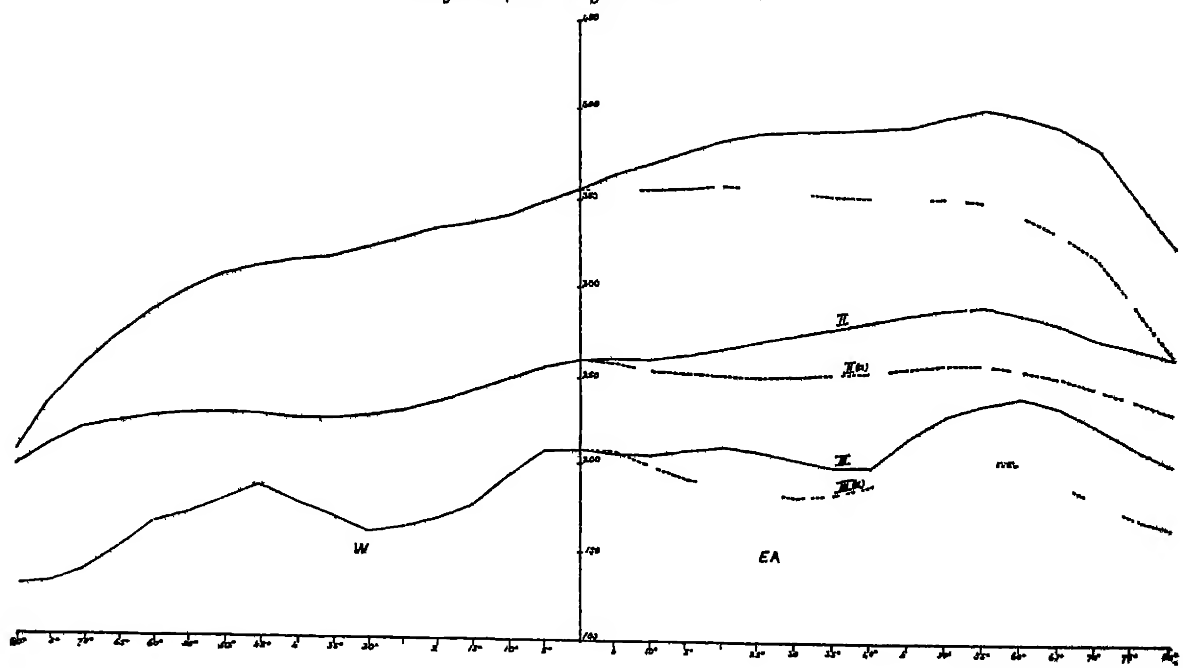
7. It remains only to see whether and, if so in what way these zones affect the long lived spots which start outside the zones and cross over to the west in their transit across the sun s disc Of course, the only way in which we can test this is to watch their behaviour from day to day or through successive stages in their journey on the solar disc. We can, for example investigate if their areas undergo any change when they cross the zones, but the problem is not one of simplicity Spots of less duration than thirteen days, start in all longitudes within their possible limits and are observed on successive days wherever they happen to be

at the time of observation. The trouble in reducing their areas to any fixed standard positions is enormous. The simplest case and at the same time one that would offer a crucial test appeared to be that of 13- or 14-day spots which start from the eastern end of the disc and travel to the western end, passing through both the zones of inhibition on their way. Here too there were some difficulties. For instance, the successive observations of two 13-day spot groups Nos. 954 and 987, as given in the Greenwich Photoheliographic Results, were at longitudes $-75^\circ.6$, $-65^\circ.5$, $-59^\circ.9$, $-36^\circ.4$, $-22^\circ.1$, $-8^\circ.6$, $+4^\circ.0$, $+12^\circ.7$, $+26^\circ.1$, $+43^\circ.8$, $+52^\circ.7$, $+70^\circ.8$, $+79^\circ.6$, and $-80^\circ.1$, $-65^\circ.0$, $-37^\circ.2$, $-25^\circ.2$, $-12^\circ.2$, $+1^\circ.3$, $+10^\circ.4$, $+29^\circ.4$, $+40^\circ.5$, $+54^\circ.3$, $+68^\circ.7$, $+80^\circ.4$, respectively, east being reckoned negative and west positive. It is evident that the comparison of the areas of a large number of spots observed at such varied longitudes cannot be undertaken before they are determined for all groups for some stated longitudes. The following method was adopted for this purpose. On a large sheet of squared paper every 5° of longitude was marked along the abscissa up to 80° on either side of a central vertical line representing the central meridian of the sun, the ordinates being made to represent the areas of spots. From the Greenwich Photoheliographic Results the areas for each 13- or 14-day spot-group at the longitudes of observation were taken and plotted on the squared paper and the points were joined by straight lines. From the curves so obtained the values of the areas at 80°, 75°, 70°, 65°, etc., on the east and west up to the central meridian were read off and entered in tabular form. In this way were reduced all the 13- and 14-day spots given in the Greenwich Photoheliographic Results for the years 1874 to 1885, excepting a very few which displayed most extravagant changes or whose areas could not be confined within the limits of the squared paper. There were 113 spot-groups studied in this way. It is true that, strictly considered, the areas so derived for the adopted standard longitudes are not quite accurate, for during the interval between any two observations the areas might have undergone irregular changes, whereas the method of reduction adopted assumes that the change during the interval has been uniform. It is believed, however, that the error due to this assumption will not be large. It may be mentioned that the same assumption has been made in order to fill wider gaps in the Greenwich Photohelio. Results, when there were no photographs available for certain days. The data obtained by the method described above give the areas of spot-groups for every 5° of longitude from 80° east to 80° west. Curve I in diagram 4 represents the mean of the areas of 113 groups, and I (*a*) by the side of it the mean of east and west combined. Although the curve shows a general deterioration in areas, as groups transit the sun's disc, there are perceptible dents in it on either side of the central meridian at the stages where the zones of inhibition are situated. In the course of plotting and tabulation it was noticed that the majority of spot-groups underwent many kinds of vicissitudes during their life on the visible disc, such as blazing up in area, acquiring or dropping out companions, splitting up into smaller spots or joining with others to form a compact one. The areas were reduced regardless of these changes, so that if the influence of the zones could be detected even under the most adverse conditions, the existence of the zones could be established beyond any doubt. During the final stages of reduction, all spots which were described as "Regular" in the Greenwich ledger and which did not exhibit any pronounced changes were noted. There were 33 spot-groups so marked, and these were totalled and averaged separately. This is represented by curve II in diagram 4. Curve II (*a*) by its side shows the mean for east and west. It is clearly seen that when the changes due to extraneous causes are removed, the influence of the zones is seen to better advantage, but even in the cases described as "Regular" the conditions were not ideal. There are indeed very few spots which are quiescent and show absolutely no changes. If we were to confine ourselves to such ideally quiescent groups only, the material for discussion will be very meagre, but it is likely that an assemblage of data given by a large number of such groups would bring out the existence of the two zones most clearly, as can be seen from curve III in diagram 4. It is the curve of the area of a single spot-group, No. 765, which is described in the Greenwich ledger as "A Regular Spot with a Small Companion." As all changes seen during the life-history of every group are briefly noted at the head of the table pertaining to each, the absence of any mention of changes shows that the group selected was a quiescent one which simply transited the sun's disc, undergoing only the general deterioration which, as already noticed, affects all spots. This group may therefore be taken as free from outside influences and may be expected to behave in an almost ideal fashion when

passing through the zones of inhibition and that is what it has done as its curve and the mean curve III (*a*) clearly show

Diagram 4

Change th Area f
13 day Sun-spots as they Cr th S n Dis



Conclusions

1 There are two zones on the sun's disc between 30 and 50 of solar longitude east and west which exercise an apparent inhibitory influence on sunspots

2. The short-lived spots tend to avoid the two zones and the areas of long lived ones are reduced to some extent while passing through them.

3 In the case of spot-groups passing the sun s disc from end to end a general deterioration in areas is noticed This requires explanat on

4 It is significant that the two zones of inhibition occupy a permanent place with respect to the sun s central meridian whose position on the sun is, as is obvious relative to the earth The origin and the physical nature of the two zones have naturally to be explained with due regard to this fact

KODAIKANAL
26th July 1932

P R CHIDAMBARA AYYAR,
Assistant.

MADRAS—PRINTED BY THE SUPERINTENDENT GOVERNMENT PRESS—1932

Kodaikanal Observatory.

BULLETIN No. XCVIII

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE SECOND HALF OF THE YEAR 1931

In pursuance of the programme of work adopted since 1st January 1923 under the auspices of the International Astronomical Union, all observatories taking spectroheliograms of the sun have been asked to co-operate with the Kodaikanal Observatory by supplying copies of their photographs on those days when the Kodaikanal records are imperfect or wanting. In response to our requirements for the second half of the year 1931, the Mount Wilson Observatory supplied calcium (K_{23} prominence plates for 47 days and Hα disc plates for 28 days ; the Meudon Observatory supplied calcium (K_3) disc plates for 4 days and Hα disc plates for 19 days ; and the Pitch Hill Observatory (Mr. Evershed's) at Ewhurst, Surrey, England, supplied one Hα disc plate.

When only incomplete or imperfect photographs for any day are available from more than one observatory, the best photograph is chosen as representing the solar activity of that day after weighting it according to its quality, and the remaining photographs are ignored.

Calcium Prominences at the Limb.

The mean daily areas and numbers of prominences photographed during the half-year by means of the K line of calcium are given below. The means are corrected for incomplete or imperfect observations, the total of 171 days for which plates were available being reduced to 159 effective days.

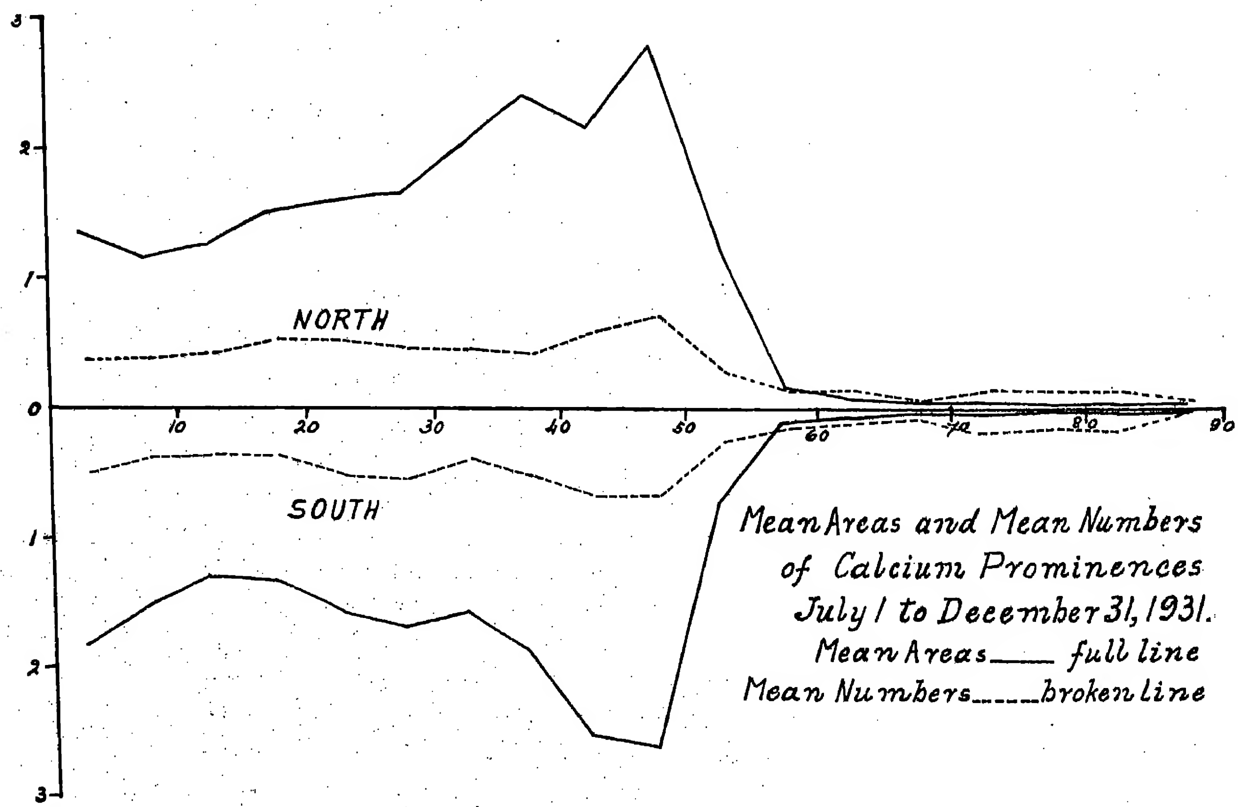
	Mean daily areas (square minutes).	Mean daily numbers.
North	1·94	5·93
South	1·89	6·20
Total ...	3·83	12·13

Compared with the previous half-year both areas and numbers show a decrease of about 6 per cent and 11 per cent respectively.

For comparison with bulletins issued prior to the co-operation of other observatories the means based on Kodaikanal photographs alone are also given, 142 days of observation being counted as 124 effective days.

		Mean daily areas (square minutes).	Mean daily numbers.
North (Kodaikanal photographs only)	... ...	2·13	6·54
South (do.)	... ...	2·08	6·74
	Total ...	4·21	13·28

The distribution of prominences in latitude is represented in the following diagram, in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude. The ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line. Compared with the previous half-year the diagram shows very little change in the distribution of activity in the various zones except for a slight fall near latitude 10°.



The monthly, quarterly and half-yearly areas and numbers, and the mean height and mean extent of the prominences on photographs from all co-operating observatories are given in Table I. The unit of area is 1 square minute of arc. The mean height is derived by adding together the greatest heights reached by individual prominences and dividing by the total number of prominences observed; the mean extent is derived by adding together the lengths of the base on the chromosphere of individual prominences and dividing by the total number of prominences.

TABLE I.—ABSTRACT FOR THE SECOND HALF OF 1931.

Months.	Number of days (effective).	Areas.	Numbers.	Daily means. Areas.	Daily means. Numbers.	Mean height.	Mean extent.
1931.						″	°
July	27½	114·6	334	4·2	12·1	33·2	5·48
August	28¾	108·6	344	3·8	12·0	34·7	4·98
September	28½	128·5	391	4·5	13·7	32·9	4·89
October	28¾	135·0	386	4·7	13·4	34·0	5·01
November ...	25¼	72·2	294	2·5	11·6	30·0	4·24
December ...	20¼	50·2	180	2·5	8·9	31·3	4·95
Third quarter ...	84¾	351·7	1,069	4·1	12·6	33·6	5·10
Fourth quarter ...	74¼	257·4	860	3·5	11·6	32·1	4·73
Second half-year	159	609·1	1,929	3·8	12·1	32·9	4·94

Distribution east and west of the sun's axis.

As in the previous half-year, both areas and numbers showed a defect at the east limb as will be seen from the following table :—

1931 July to December.	East.	West.	Percentage East.
Total number observed	940	979	48·98
Total areas in square minutes	279·6	329·5	45·90

Hydrogen Prominences at the Limb.

During the half-year, photographs of the prominences in hydrogen light were taken in this observatory on 119 days which were counted as 109 effective days. The mean daily areas, in square minutes of arc, of hydrogen prominences are given below :—

	Mean daily areas (square minutes).
North	0·76
South	0·63
Total ...	1·39

Compared with the previous half-year, Hα prominence areas show a decrease of about 3 per cent. The percentage of Hα areas to calcium areas is 33, nearly the same as in the previous half-year. The curve of distribution of Hα prominences is similar to that of calcium prominences. The northern preponderance is still more marked in the case of Hα prominences than for calcium ones, the ratio of the northern areas to the southern being 1·21 and 1·02 for Hα and K prominences respectively.

Metallic prominences

Only one metallic prominence was observed during the half year. Its details are given below —

TABLE II —LIST OF METALLIC PROMINENCES—JULY TO DECEMBER 1931

Date	Time IST	Base	Latitude North	Latitude South	Limb	Height.	Lines
1931	H M			°		″	
Nov 16	8 39	2	10		E	10	4924 1, 5016, 5018 6, b_4, b_3, b_2, b_1, 5234 8, 5276 2, 5316 8, D_3, D_1 and 7065

Displacements of the hydrogen lines

Particulars of the displacements observed in the chromosphere and prominences are given in the following table —

TABLE III —DISPLACEMENTS OF THE HYDROGEN LINE

Date		Time IST	Latitude North	Latitude South	Limb	Displacement Red	Displacement Violet	Displacement Both ways	Remarks
1931		H M	°			A	A	A	
July	5	9 8	45		E	1			At top
	16	9 36	10		E	0 5			Do
	20	8 38	8		W		1		At base
	22	9 0		27	W		Slight		At top
		9 5	25		W	3			Do
	23	9 19		82	W	2			In chromosphere
		9 8	2		W	1			At base
	26	9 5		7	E	1			At top
		8 58		57 5	W	1			Do
	31	9 56	13		E	1			At base
August	18	8 49	45 5		E	1			Do
		8 40		33 5	W		Slight		Do
September	2	9 29	22 5		W	2			At top , extends over 5° from 20° to 25°
	4	8 55		74 5	W			Slight	In chromosphere
		8 52		35 5	W	1			At top
		8 45		1	W	0 5			Do
		8 40	82		W	Slight			In chromosphere
	5	8 58	58 5		E	Do			Do
		9 0	12		E		Slight		Do
		8 42	62		W	0 5			Do
	16	9 3		70 5	E		1		At top
	18	9 1		7	E			0 5	At base
		8 51		65	W	1 5			Do
		8 44	11		W	0 5			In chromosphere
	20	9 23		61	E		0 5		Do
	23	9 25	8		E	Slight			At top
		9 47	54		W		Slight		Do
	26	9 9	53		E	1			In chromosphere
	27	8 52	21		E	Slight			At top
October	1	8 54		7	W		1		In chromosphere
	2	8 55		16	W	1			At top extends over 2° from 15° to 17°
	9	8 55		58 5	W	2			At top
		8 52	12		W		Slight		Do
	11	9 17	55		E		1		Do
	13	8 43		44 5	W	1			
	30	8 55	31		E	0 5			At base

Date.	Time I.S.T.	Latitude.		Limb.	Displacement.			Remarks.
		North.	South.		Red.	Violet.	Both ways.	
1931.	H. M.	°	°		A.	A.	A.	
November 8	9 6	27		W		1		At base.
9	9 34	19		W		1		
14	8 58		25	W	Slight			At top.
16	8 29	39		E	0·5			At base.
	8 39	10		E		0·5		Do.
	8 39	1		E	1			At top.
18	9 37		50	E	0·5			Do.
22	10 10	29		E	2			In chromosphere.
	10 50	3		W	1			At top.
	10 49	11		W		1		
23	8 24		2	E	0·5			At base.
December 5	10 26	37		W		Slight		At top.
18	10 35	26·5		E	1			At top; extends over 3° from 25° to 28°.
	9 34	15		W	1	1		To red at top, to violet at base.
19	9 0		20	E	1			At base.
	9 23		11	W	0·5			At top.
28	10 36		34	W	1·5			Do
	10 36		28	W	1			In chromosphere.
	10 34		5·5	W		0·5		At top.
31	8 54		52·5	W		1		At base, extends over 3° from 51° to 54°.

The total number of displacements was 57 as against 188 in the previous half-year and their distribution was as follows:—

Latitude.	North.	South.
1°–30°	21	12
31°–60°	9	8
61°–90°	2	5
Total ...	32	25
East limb		23
West limb...		34
Total ...		57

Reversals and displacements on the sun's disc.

Seventy-nine bright reversals of the Hα line, 74 dark reversals of the D_3 line and 9 displacements of the Hα line were observed during the half-year. Their distribution is given below:—

	North.	South.	East.	West.
Bright reversals of Hα	54	25	41	38
Dark reversals of D_3	51	23	38	36
Displacements of Hα	7	2	7	2

Seven displacements were towards the red and two towards the violet.

Prominences projected on the disc as absorption markings.

Photographs of the sun's disc in Hα light were available from Kodaikanal and the co-operating observatories for a total of 175 days, which were counted as 166 effective days. The mean daily areas of Hα absorption markings (corrected for foreshortening) in millionths of the sun's visible hemisphere and their mean daily numbers are given below:—

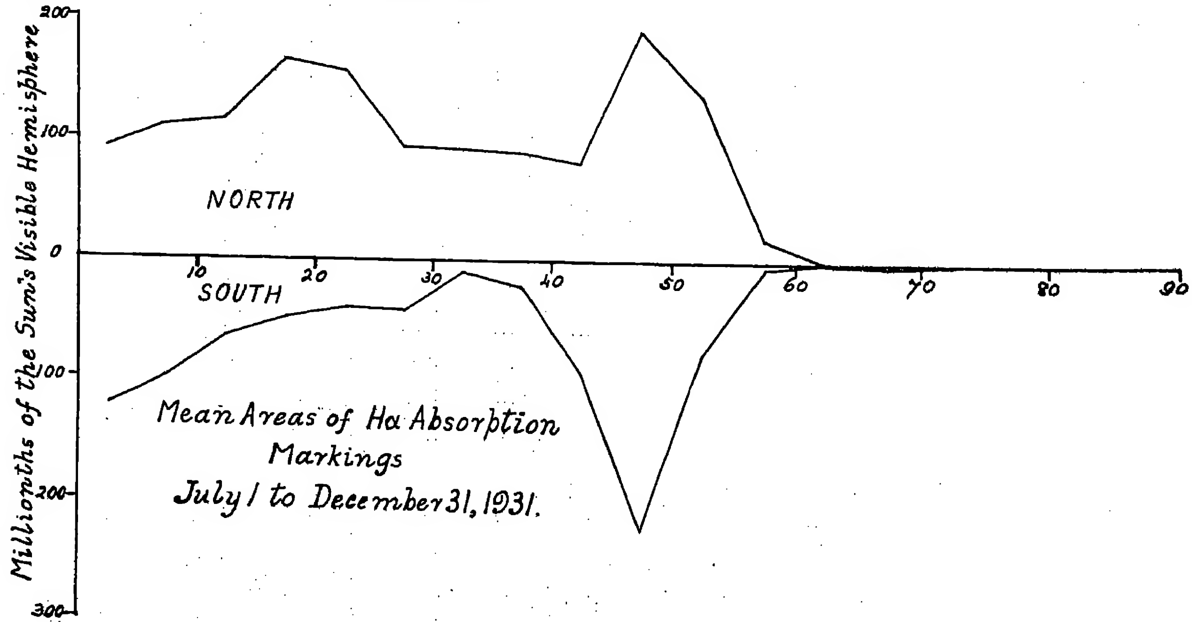
	Mean daily areas.	Mean daily numbers.
North	1,338	8·55
South	841	5·54
Total ...	2,179	14·09

The above show a decrease of less than 1 per cent in areas and of about 8 per cent in numbers, compared with the previous half-year.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 133 days of observation being reckoned as 126 effective days.

	Mean daily areas.	Mean daily numbers.
North (Kodaikanal photographs only)	1,300	8·62
South (do.)	831	5·48
Total ...	2,131	14·10

The distribution of the mean daily areas in latitude is shown in the following diagram. The high latitude peaks in both the hemispheres noticed in the previous half-year have advanced 5° towards the poles and the small peak near 20° in the south has disappeared.



The areas and numbers show an eastern defect, the percentage east being 46 in both.

The areas of Hα absorption markings uncorrected for foreshortening are given below :—

	Mean daily areas.
North	769
South	454
Total ...	1,223

The uncorrected areas amount to 56 per cent of the corrected ones, the same as in the previous half-year. The curve of distribution in latitude is similar to that for the corrected areas as usual.

Thanks are due to the co-operating observatories for the photographs supplied by them.

KODAIKANAL,
25th October 1932.

K. R. RAMANATHAN,
Acting Director, Kodaikanal Observatory.

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Kodaikanal Observatory.

BULLETIN No. XCIX.

ON THE RESONANCE LINES OF THALLIUM AND THEIR PROBABLE ABSENCE IN THE SUN

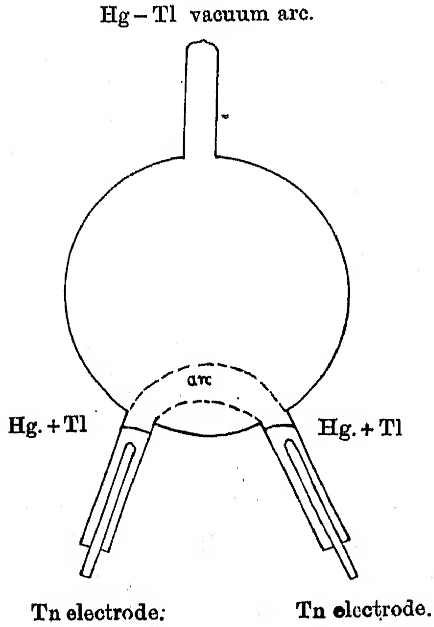
BY

A. L. NARAYAN, M.A., D.SC.

Abstract.—Using a specially constructed vacuum arc containing a two per cent amalgam of mercury and thallium, the wavelengths of the two resonance lines of Thallium $\lambda\lambda$ 5351 and 3776 (6^2P-7^2S) have been determined by the interferometer method and their intensity variation with current has been studied. The fine structure of these lines has been investigated by using a quartz Lummer-Gehrcke plate (8 mm × 200 mm), a glass Lummer-Gehrcke plate (4·8 mm × 135 mm) and etalons of fused silica plates 2 and 2·5 mm in thickness. The probability of the existence of thallium in the sun has been discussed.

The identification of Fraunhofer lines with those of elements known on the earth is of special interest and importance in view of the fact that, apart from other things, it tells us what constituents are common to the sun and the earth. One of the important methods of identification is based on coincidences with the solar lines. It requires accurate determination of wavelengths. Thallium[1] is represented in the solar spectrum by the two lines 5350.505 and 3775.712 of intensities (– 3) and (– 2) respectively which are the most persistent lines of the element. The existing laboratory measures are correct only to two decimal places. Owing to the fact that the pressures in the reversing layer and chromosphere are very minute the wavelengths in the vacuum arc should furnish an accurate basis of comparison of laboratory wavelengths with solar wavelengths. No attempts have thus far been made to determine the wavelengths of these lines in vacuum. In order to determine whether traces of thallium are to be found in the sun by a more accurate investigation, experiments were started by the author to determine the wavelengths of the important arc lines of thallium in vacuum and to study the behaviour of these lines under different conditions of excitation. In order to eliminate self-reversal and to produce sharp lines, a special type vacuum arc lamp (Fig. 1) was constructed. It was made of pyrex glass into which tungsten electrodes were sealed. The side tubes carrying the electrodes contained a 2 per cent amalgam of mercury and thallium.

Fig. 1.
Hg – Tl vacuum arc.



The cathode was throughout kept cooled by surrounding it with running water. Owing to the very low partial pressure of thallium the lines were found to be extremely sharp. At the same time the lines of mercury served as standards of comparison for wavelength measurements. The wavelengths of the lines were determined by using fused silica etalon plates of different thicknesses. The ring system was projected on the slit of the spectrograph by means of an achromatic focussing lens. Besides this, photographs were obtained also of the arc in air using the second order of a parabolic grating of 11 feet focus. A 12 mm Pfund type of arc with iron poles, carrying a current of four amperes was used. A small quantity of the metal or its salt was placed in a cupshaped hollow

in the lower electrode. In this way iron lines which served as standards were photographed simultaneously. It is interesting to note in this connection that with smaller concentration of Tl more consistent and regular results were obtained. The investigations of Dr. T. Royds on the apparent tripling of certain lines in the Arc Spectra (Proceedings of the Royal Society, A, Vol. 107, pp. 360–367) which showed that the behaviour of the Tl 5350 line can be explained as different stages in the self-reversal, will explain the reason for this behaviour.

Wavelength Determination.

For rays of light of wavelength λ incident on an etalon of thickness t, a bright ring will be produced in the focal plane of the lens if $n+\alpha=2t\cos i$. If α is the fractional part of the order of interference at the centre of the ring system, d_p and d_q be the measured diameters of any two rings p and q of the system it can be easily shown that

$$\alpha = \frac{(p-1)\,dq^2-(q-1)\,dp^2}{dp^2-dq^2}$$

The values of α can therefore be calculated from a knowledge of the diameters of any two rings. Knowing α the value of λ can be determined from the relation $2t = n_0\lambda = (n+\alpha)\lambda$.

To determine the thickness t with precision, the etalon was first measured with a gauge. The value was then improved from measurements of known standard mercury lines. The following results were obtained for the thickness of the two etalons used in this investigation:—

	By measurement.	By calculation.
Etalon No. 1	2.55 mm.	2.55397 mm.
Etalon No. 2	1.99 mm.	2.0110 mm.

Experiments show that the penetration into the silver film depends on the wavelength and the distance between the two films varies for wavelength to wavelength. This is interpreted as being due to the change of phase at reflection from silver which varies slightly with wavelength. The usual method of finding the small correction required on this account is by obtaining measurements for the same film but for different thicknesses. In these experiments, it was not possible to adopt this method as the etalons were plane parallel plates of silica. Using the wavelength values of Hg, given above, the values of (phase-change) for different wavelengths were obtained from the following equation :—

$$\epsilon_s = P_1\frac{\lambda_1}{\lambda_2}\left(1+\frac{d_1^2}{8R^2}-\frac{d_2^2}{8R^2}\right)-P_2$$

When the values for phase-change were obtained for each of the silverings used in these experiments, it is surprising to find that the deviations in the values of phase-change are decidedly large. Attempts will be made shortly to deposit films of silver by cathode discharge and by evaporation in vacuum and determine the range of variation of phase-change. The following mean values were actually obtained for phase-change :—

$$\epsilon = -\ .020 \text{ for } \lambda = 3775.7$$
$$\text{and } \epsilon = -\ .006 \text{ for } \lambda = 5350.5$$

For the determination of wavelengths of the two resonance lines of Tl the following Hg lines were used as standards :—

λ I.A.	λ I.A.	λ I.A.
5790.659 A.	4916.051 A.	3662.880 A.
5769.597 A.	4358.342 A.	3654.832 A.
5460.741 A.		

From the deviations of the individual measurements of the diameters of the rings the probable error of an individual measure is found to be .0035A. In the following table are given the mean values of the wavelengths of the two resonance lines in vacuum arc, by the interferometer method:—

Line designation.	Vac. arc.	In sun.	Sun-Arc.
$6^2P_{\frac{3}{2}}-7^2S_{\frac{1}{2}}$	5350.527	5350.505	−.022
$6^2P_{\frac{1}{2}}-7^2S_{\frac{1}{2}}$	3775.7241	3775.712	−.012

The mean values of λ obtained in arc reversals by the parabolic grating are

5350.4980 A*

and 3775.7297 A.

As the effect of pressure on these wavelengths is not known with definiteness, these values could not be reduced to vacuum.

In Tl as in the allied elements Hg and Bi, complex structure is manifest to a high degree. A study of the fine structure of the two resonance lines by the author has shown that the lines have four or more components spread over a range of nearly 0.15A. On account of this highly complex structure, naturally the accuracy of the results will by no means be the highest of which the method is susceptible. This renders comparison with solar lines difficult.

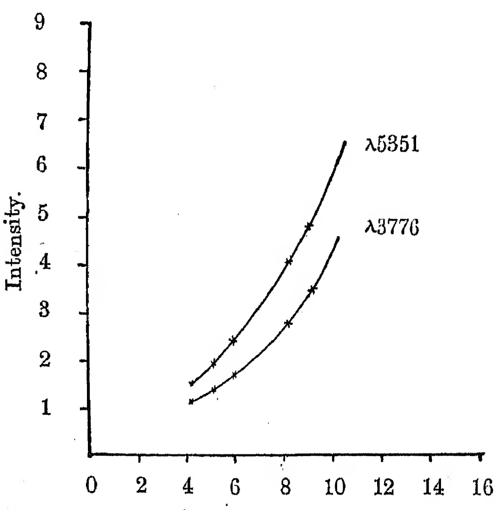
Experiments were tried to determine how the intensity of these resonance lines, produced by the above method, varied with current. Exposures were taken with currents varying from 3 to 10 amperes through the arc. The spectrograms were then measured on a Cambridge Microphotometer for densities.

If d is the density of the line,

$$d = \log_{10} \frac{I_1}{I_2} = \log_{10} \frac{w_1}{w_2}$$

where I_1, I_2 are the intensities of light through the blackened and unblackened portion respectively and w_1 and w_2 are the electrometer deflections. In Fig. 2, the intensities of the lines are plotted against the current and it will be seen that above 6 amperes there is a rapid increase in intensity with current. The increase is more marked in the case of λ5351A.

Fig. 2.



To determine the intensity of the lines in the source in each case density-intensity curves were first plotted for the two lines in the following way. Light from Hg-Tl vacuum arc, carrying a steady current of four amperes is made to fall on a ground-glass screen by a condensing lens. Light from the central uniformly illuminated area on this screen is then allowed to fall on the slit of the spectrograph and spectrograms were obtained with slit widths of 0.4, 0.8, 1.2 and 1.6 mm and the same exposure times. The intensity of light coming through different slit widths and the same exposure as spectrograms is proportional to the slit-width. The plate was microphotometered for density values. Intensity-density curves were constructed from these data at the wavelengths of the two resonance lines.

Hyperfine Structure of the Resonance Lines.

Several investigators have found from time to time that the arc lines of Tl exhibited a fine structure and that the fine structure separations are much smaller than the splitting due to the couplings between the extra-nuclear electrons. Fine structure observed in spectral lines might be due to (*a*) the "Isotope Effect" arising from the difference in the structure of the nucleii and (*b*) a spinning nucleus. In the latter case it is the interaction between the magnetic nucleus and the resultant mechanical moment of the extra nuclear electrons "J" that contributes to the hyperfine splitting of the levels. By analogy with the spinning electron, a spinning nucleus is associated with a mechanical moment ($= \frac{ih}{2\pi}$) where i is the corresponding spin moment quantum number of the nucleus. It has been shown in recent years that there is a close similarity between the ordinary multiplets and the hyperfine multiplets. The theory predicts that the fine structure separations

* It is quite possible that this low value is due to the high density employed blending the main components.

follow the interval rule accurately From the hypothesis of nuclear spin several investigators obtained intensity formulae which are found to hold good exactly in the case of several h f s There are, however, large discrepancies between the predicted and observed intervals even in relatively simple cases

The fine structure of the arc lines of Tl has previously been studied by Ruark and Chenault[2], by Back[3], by Wali Muhammad[4], and more recently by McLennan and Crawford[5], by Schular and Keyston[6] and by Jackson[7] There seem to be considerable differences between the results of the different investigators The deviations in some cases are so large that it is difficult to interpret them as such

Fine structure patterns are not generally completely resolved owing to the effect of electric fields and pressures in broadening spectral lines Owing to the extremely low partial pressure of Tl vapour in the above mentioned source, it was felt that it would be particularly useful for the study of fine structure A systematic study of the fine structure of the arc lines of Tl, particularly the two resonance lines, was therefore undertaken by the author, using for the purpose a quartz Lummer-Gehrcke plate (8 mm × 200 mm), a glass Lummer-Gehrcke plate (4 8 mm × 135 mm) and fused silica plate etalons of 2 and 2 5 mm thickness

Discussion of Results

As there seemed to be a considerable amount of divergence in the results of the earlier investigators, it is proposed to deal in the following lines, only the more recent results

In a note to "Nature" (October 17, 1931) it was pointed out by the author that λ 5351A was a quartet and that its structure could be interpreted by assigning an isotope displacement of about 0 05 cm⁻¹ and that the line λ 3776 exhibited a very complex structure consisting of five components though no isotope effect was found in this case Schuler and Keyston independently found a similar isotope displacement in the case of λ 5351 while McLennan and Crawford discovered no trace of isotope shift

Schuler and Keyston and Jackson found the line λ 3776 to be a triplet and the structure was interpreted by the former by supposing the absence of an isotope shift Further observations were made by the author on the structure of this line under different conditions of excitation These subsequent photographs clearly showed the line to be a group of six components The following table gives the structure of these lines as observed by the author —

Line	Fine structure components		In A	In cm^{-1}
λ 5351	a		0 000	0 000
		A	− 0 015	0 053
$6^2P_{\frac{3}{2}} - 7^2S_{\frac{1}{2}}$	b		− 0 110	0 385
		B	− 0 128	0 448
λ 3776	a		0 000	0 000
		A	− 0 007	0 050
$6^2P_{\frac{1}{2}} - 7^2S_{\frac{1}{2}}$	b		− 0 054	0 380
		B	−0 064	0 450
			−0 117	0 820
	c		− 0 154	1 080
		C	− 0 165	1 150

From a consideration of the distribution of the satellites indicated in the above table it is found that the complex structure of λ 3776 could be quantitatively interpreted if we suppose that the "$^2P_{\frac{1}{2}}$" term like the "$^2P_{\frac{3}{2}}$" term shows an isotope displacement of about 0 060 cm^{-1} Microphotometric traces of the Lummer

pattern for λ 3776 for two different current values are shown in Fig. 3. The level schemes are shown in Fig. 4. There is however a component at − 0·117A which does not find a place in the above scheme.

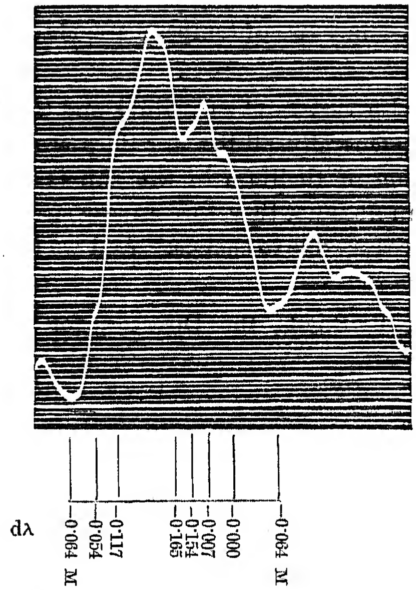


Fig. 3 (*a*).

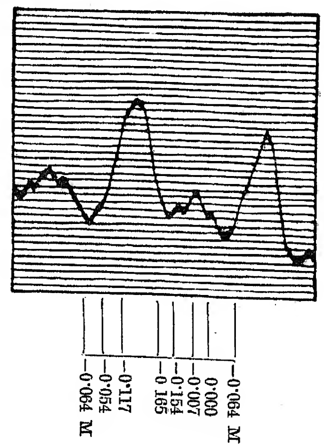


Fig. 3 (*b*).

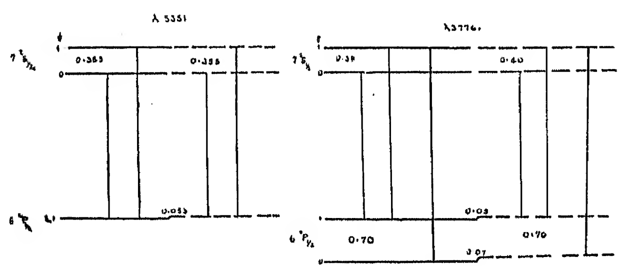


Fig. 4.

This has also been observed by Wali Muhammad. The structure now given removes the anamoly noted by Schuler and Keyston in the isotope displacement of $^2P_{\frac{1}{2}}$ term. It is interesting to note in this connection that Jackson [8] also made more careful observations and revised his former results and recently proposed a level scheme which is substantially the same as mine. Only, the satellite at − 0·117A is not found in his measurements.

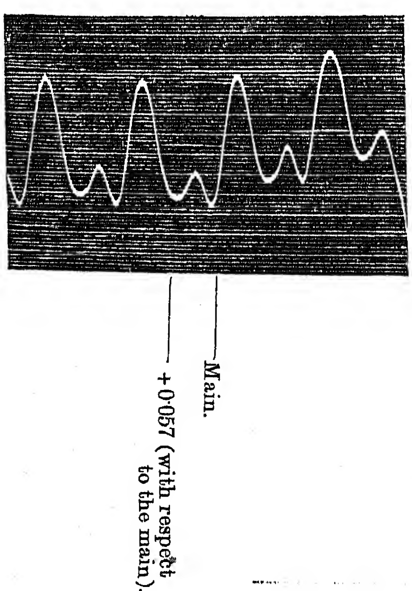


Fig. 5.

As has recently been pointed out in a note in "Current Science," [9] it is very remarkable that slight variations in the excitation result in marked changes in the relative intensities of the components as will be seen from the microphotometric traces. Pressure conditions seem to be very important in the excitation and therefore in the intensity relationships of the fine structure patterns. It is nevertheless difficult to see how these slight variations in excitation can influence the interaction between the nucleus and the electron shell. Fig. 5 represents the microphotometric trace of the same line, when photographed with a fused silica plate etalon of thickness 2 mm and shows the satellite at 0·057A (with respect to the main) which is obviously almost as intense as the main line itself.

In the case of spectral lines like these which exhibit a complex structure, particularly when there are two or more components whose intensities are nearly equal, it would appear more reasonable to take the centre of gravity of these components constituting the radiation as the position for the wavelength measurements.

Absorption of Resonance Lines.

Some time back the author studied the absorption of λλ5351 and 3776 of Tl by a column of nonluminous vapour. It was found that as the temperature of the vapour was raised, general absorption of the central doublet commenced at about 600°C and it was completely extinguished at about 800°C while at this temperature the satellite was but a very little absorbed. With further increase of temperature, absorption of the satellite took place till it was complete at about 1000°C.

Further, in view of the fact that both these lines coincide with very faint solar lines and the line λ 5351 does not appear to be strengthened in the spot spectrum while generally all the arc lines are considerably enhanced, it would appear that the evidence for the identification of thallium in the sun is very meagre. The available evidence for Tl as a probable constituent of the sun does not therefore appear strong enough to justify its inclusion. It is more probable that these coincidences are due to chance. And we must conclude that there is no evidence at present for the existence of Tl in the sun.

In conclusion, it is a pleasure to express my thanks to Dr. T. Royds, the Director, for his unfailing interest.

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KODAIKANAL OBSERVATORY,
27th December 1932.

A. L. NARAYAN,
Assistant Director.

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Kodaikanal Observatory.

BULLETIN No. C.

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE FIRST HALF OF THE YEAR 1932.

In pursuance of the programme of work adopted since 1st January 1923 under the auspices of the International Astronomical Union, all observatories taking spectroheliograms of the sun have been asked to co-operate with the Kodaikanal Observatory by supplying copies of their photographs on those days when the Kodaikanal records are imperfect or wanting. In response to our requirements for the first half of the year 1932, the Mount Wilson Observatory supplied calcium (K_{23}) prominence plates for 17 days and H_α disc plates for 6 days; the Meudon Observatory supplied calcium (K_3) disc plates for 5 days and H_α disc plates for 12 days.

When only incomplete or imperfect photographs for any day are available from more than one observatory, the best photograph is chosen as representing the solar activity of that day, after weighting it according to its quality, and the remaining photographs are ignored.

Calcium Prominences at the Limb.

The mean daily areas and numbers of prominences photographed during the half-year by means of the K line of calcium are given below. The means are corrected for incomplete or imperfect observations, the total of 182 days for which plates were available being reduced to $172\frac{1}{2}$ effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North	1·31	5·50
South	1·27	5·25
Total ...	2·58	10·75

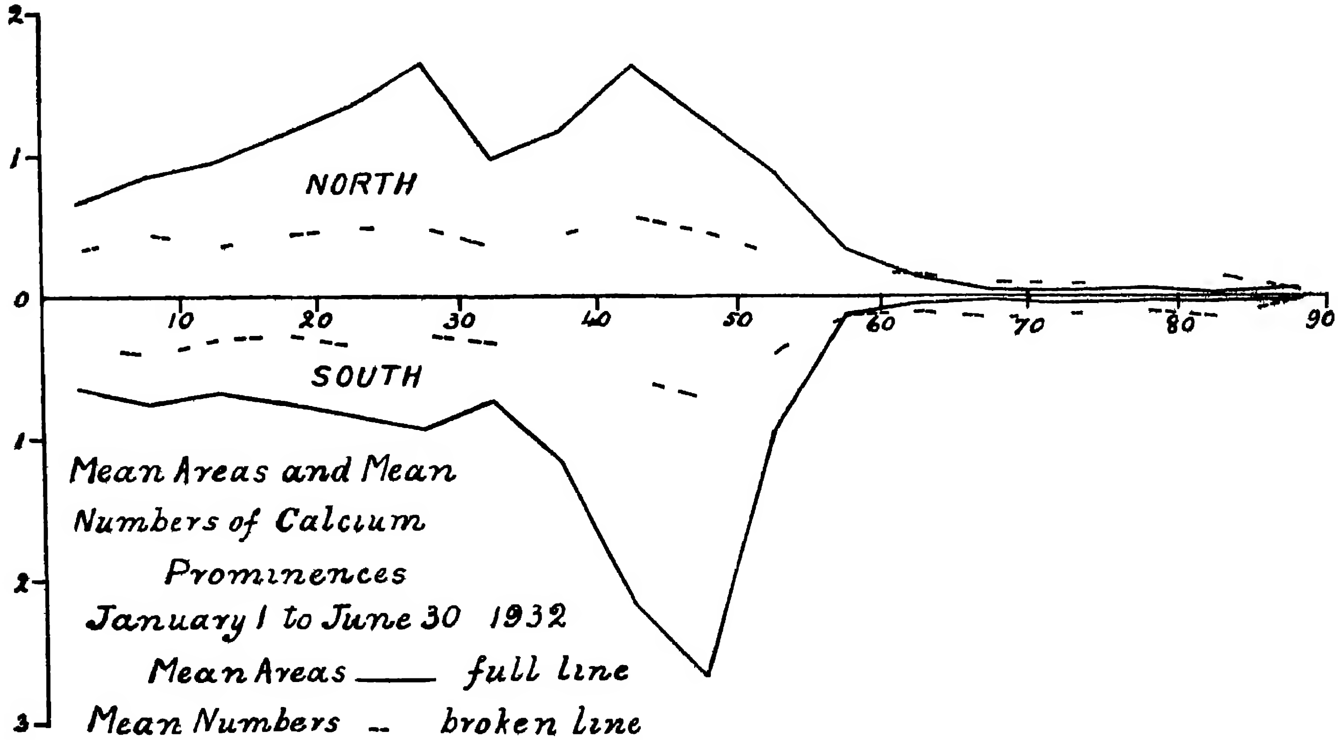
Compared with the previous half-year, areas and numbers show a decrease of about 33 per cent and 11 per cent respectively.

For comparison with bulletins issued prior to the co-operation of other observatories the means based on Kodaikanal photographs alone are also given, 171 days of observation being counted as 158 effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North (Kodaikanal photographs only)	1·35	5·58
South (do.)	1·32	5·36
Total ...	2·67	10·94

The distribution of prominences in latitude is represented in the following diagram, in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude. The ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line. Compared with the previous half-year, the distribution of activity is almost the same in the southern hemisphere but there are two peaks in the northern hemisphere in the belts 25°—30° and 40°—45°, as against

one in the belt 45 —50 in the previous half year The peak that occurred in the belt 45 —50 in the northern hemisphere during the previous half year has shifted 5 towards the equator



The monthly quarterly and half yearly areas and numbers and the mean height and mean extent of the prominences on photographs from all co operating observatories are given in Table I The unit of area is 1 square minute of arc The mean height is derived by adding together the greatest heights reached by individual prominences and dividing by the total number of prominences observed the mean extent is derived by adding together the lengths of the base on the chromosphere of individual prominences and dividing by the total number of prominences

TABLE I—ABSTRACT FOR THE FIRST HALF OF 1932

Months 1932	Number of days (effective)	Areas	Numbers	Daily mean Areas	Daily mean Numbers	Mean height	Mean extent
January	29¾	87 1	33	2 9	11 3	30 3	4 70
February	27	81 4	336	3 0	12 4	28 4	3 61
March	29½	9 2	337	3 1	11 4	31 6	4 33
April	28¾	72 3	297	2 5	10 3	32 8	3 71
May	28½	54 6	264	1 9	9 3	31 3	3 48
June	29	57 4	284	2 0	9 8	32 8	3 92
First quarter	86¼	259 7	1 010	3·0	11 7	30 1	4 21
Second quarter	86¼	184 3	845	2 1	9 8	32 1	3 71
First half year	172½	444 0	1 855	2 6	10 7	31 0	3 98

Distribution East and West of the Sun s Axis

As in the previous half year both areas and numbers showed a defect at the east limb as will be seen from the following table —

1932 January to June	East	West	Percentage east
Total number observed	884	971	47 65
Total areas in square minutes	204 8	239 1	46 14

Hydrogen Prominences at the Limb.

During the half-year, photographs of the prominences in hydrogen light were taken in this Observatory on 158 days which were counted as 141½ effective days. The mean daily areas of hydrogen prominences in square minutes of arc, are given below :—

	Mean daily areas (square minutes).
North	0·49
South	0·52
Total ...	1·01

Compared with the previous half-year, H_α prominence areas show a decrease of about 27 per cent. The percentage of $H\alpha$ areas to calcium areas is 38. The curve of distribution of H_α prominences is similar to that of calcium prominences.

Metallic Prominences.

Two metallic prominences were observed during the half-year. The details are given below :—

TABLE II.—LIST OF METALLIC PROMINENCES—JANUARY TO JUNE 1932.

Date.	Time I.S.T.	Base.	Latitude. North.	Latitude. South.	Limb.	Height.	Lines.
1932.	H. M.	°	°	°		″	
January 2 ..	12 25	1	16·5	...	E	10	b_4, b_3, b_2, b_1, D_2 and D_1.
7 ...	9 20	3	...	12·5	W	25	b_4, b_3, b_2, b_1, D_2 and D_1.

Displacements of the Hydrogen Line.

Particulars of the displacements observed in the chromosphere and prominences are given in the following table :—

TABLE III.—DISPLACEMENTS OF THE HYDROGEN LINE.

Date.		Time I.S.T.	Latitude. North.	Latitude. South.	Limb.	Displacement. Red.	Displacement. Violet.	Displacement. Both ways.	Remarks.
1932.		H. M.	°	°		A.	A.	A.	
January	1	8 55	79·5		E		1		At base.
	2	12 36		27	W		Slight.		In chromosphere.
	5	9 5	72·5		W	Slight			At top.
	6	9 40	20		W		1		Do.
		9 17		58	E	Slight			In chromosphere.
	7	9 20		12·5	W		2		At top.
	9	9 26		88·5	W	2			Do.
	10	9 0		32	W	0·5			Do.
	17	9 17		10	W		0·5		At base.
		9 15		3	W	1			At top.
	18	8 56	45		E		0·5		At base.
		9 7	30		E	Slight			At top.
	19	8 47	32		W	Slight			
	20	9 24	74		E		Slight		At top.
		9 19		10	E		1		A detached filament displaced throughout.

Date.		Time I.S.T.		Latitude. North.	Latitude. South.	Limb.	Displacement. Red.	Displacement. Violet.	Displacement. Both ways.	Remarks.
1932.		H.	M.	°	°		A.	A.	A.	
	24	9	47		7	E	1			In chromosphere.
	25	9	12		39	W		Slight		Do.
	26	8	56	17		E		0·5		
		8	58	1		E	Slight			
		8	48	79		W			1	
	29	9	15	66		W	0·5			At base.
		9	14	81		W	Slight			Do.
	31	8	51	83		E		0·5		
		8	58		24	W		0·5		
February	1	9	8		1	E		0·5		At base.
	2	9	16		14	W		0·5		Do.
	4	8	54	36·5		W	1			At top.
		8	54	39·5		W	2·5			At top; extends over 6° from 37° to 43°.
	7	9	40	42·5		E	1			At top.
	8	9	4	12		W		0·5		At base.
	10	15	14		61·5	E		Slight		Do.
	11	9	6		3·5	E		2·5		At top.
	15	8	44		46	E		0·5		At base.
	16	8	37	74·5		E		Slight		In chromosphere.
	23	8	52		10	W		0·5		
	26	9	33		26	W	1·5			At top.
	27	10	1		12	W		1		Do.
	3	9	14	14		W		0·5		At top.
	5	9	41	4		W	Slight			Do.
	7	10	15	23·5		E	1			Do.
	10	9	0	41		E	1			In chromosphere.
		8	47	4		W	Slight			Do.
	11	9	48	16		W	0·5	1·5		
	13	10	24	41		E	Slight			At top.
	20	8	34	4		W	1			At top; extends over 4° from + 2° to + 6°.
		8	30	48·5		W	1			At top.
	21	8	50		32·5	W	0·5			At top; extends over 2° from − 32° to − 34°.
	28	8	54	49·5		W	1			At top.
	31	9	13		29	W	0·5			Do.
April	1	10	59	36		E	1			At top.
	2	10	1	22		E	1			Do.
	5	9	0		24	W		1		
	7	9	5	5		E	1			At top.
	9	9	4	Equator		E	1			At base.
	14	9	9		29·5	W	1			At top.
		9	8	6		W	0·5			In chromosphere.
	16	9	31		20	E	Slight			At base.
	18	8	30	20·5		W	Slight			In chromosphere.
	25	10	7		81·5	W		0·5		At base.
	26	9	35	68·5		E	0·5			In chromosphere.
		9	30		54	W	0·5			Do.
	28	9	21		57·5	E	0·5			Do.
	29	9	44	55·5		W	0·5			
	30	10	17	15·5		W	3			At top.
May	1	9	37	11		W		0·5		At top.
	2	8	34	15		W		Slight		At base.
		8	34	18		W	1			At top.
	3	9	17		16	W	0·5			In chromosphere.
	6	9	0	67		W		Slight		At top.
	12	8	50	5		W		0·5		In chromosphere.
	13	9	9		72·5	W		1		Do.
		8	39	42		W		0·5		Do.
	29	9	30	9		W	1			At top.
June	6	9	7		9	E		0·5		At top.
	10	9	17		48	W	0·5			Do.
		9	16		39	W	1·5			Do.
	20	9	48		68·5	E		Slight		Do.
	21	9	14	14		E	0·5			Do.
		8	45	18		W		0·5		At base.

The total number of displacements was 80 as against 57 in the previous half-year and their distribution was as follows :—

	North.	South.
Equator	1	...
1° to 30°	24	19
31° to 60°	12	9
61° to 90°	10	5
Total ...	47	33
East limb	...	29
West limb	...	51
Total ...		80

Reversals and Displacements on the Sun's Disc.

One hundred and ten bright reversals of the H_α line, 100 dark reversals of the D_3 line and 8 displacements of the H_α line were observed during the half-year. Their distribution is given below :—

	North.	South.	East.	West.
Bright reversals of H_α	65	45	47	63
Bright reversals of D_3	61	39	40	60
Displacements of H_α	6	2	4	4

Seven displacements were towards the red and one towards the violet.

Prominences projected on the Disc as Absorption Markings.

Photographs of the sun's disc in H_α light were available from Kodaikanal and the co-operating observatories for a total of 177 days, which were counted as 171 effective days. The mean daily areas of H_α absorption markings (corrected for foreshortening) in millionths of the sun's visible hemisphere and their mean daily numbers are given below :—

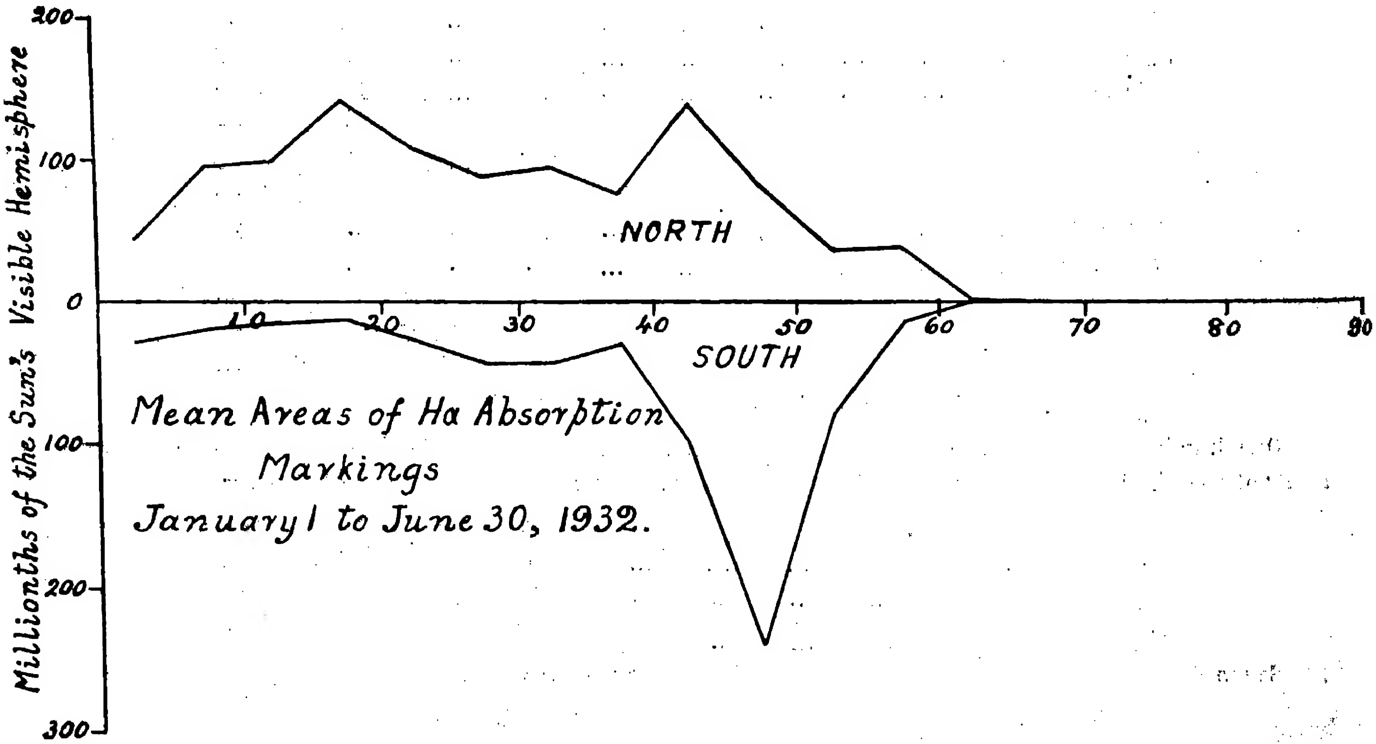
	Mean daily areas.	Mean daily numbers.
North	1,057	6·89
South	657	3·88
Total ...	1,714	10·77

The above show a decrease of 21 per cent in areas and of 24 per cent in numbers, compared with the previous half-year.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 164 days of observation being reckoned as 156 effective days.

	Mean daily areas.	Mean daily numbers.
North (Kodaikanal photographs only)	1,003	6·37
South (do.)	629	3·65
Total ...	1,632	10·02

The distribution of the mean daily areas in latitude is shown in the following diagram. The high latitude peak in the northern hemisphere has shifted 5° towards the equator while that in the southern hemisphere persists in the belt 45°–50° :—



The areas and numbers show an eastern defect, the percentage east being 48 and 47 for areas and numbers respectively. The areas of H_α absorption markings uncorrected for foreshortening are given below :—

	Mean daily areas.
North	553
South	318
Total ...	871

The uncorrected areas amount to 51 per cent of the corrected ones as against 56 per cent for the previous half-year.

The curve of distribution in latitude is similar to that for the corrected areas as usual.

Thanks are due to the co-operating observatories for the photographs supplied by them.

KODAIKANAL,
25th February 1933.

T. ROYDS,
Director, Kodaikanal Observatory.

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THE HYDROGEN CONTENT OF PROMINENCES

BY

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Abstract.—The enormous value obtained by Pannekoek and Doorn for the density of hydrogen in the prominences they observed during the total solar eclipse of 1927 is due to their hypothesis of a condition resembling thermodynamic equilibrium in the prominences.

It is shown that such an assumption must automatically lead to high values for the density, independent of the intensities observed and that it is inconsistent with conditions of line-absorption and radiation.

It is also sought to explain how the intensity of a particular Balmer line, such as $H\gamma$, can provide us with no clue to the number of hydrogen atoms in the ground level, if the state is not one of thermodynamic equilibrium. This number can be found only from a knowledge of the intensities of the Lyman lines.

An attempt is made to estimate the density of hydrogen in prominences, using Pannekoek and Doorn's data of intensities of the Balmer lines to derive the number of atoms in the second quantum state; the probable number of atoms in the first quantum state absorbing the Lyman lines is, in the absence of adequate data, guessed at. A very rough upper limit to the density of hydrogen is arrived at of the order of 1,000 atoms per c.c.

The density of Ca^+ atoms in the prominences of Pannekoek and Doorn is recalculated. After applying certain corrections (indicated by Pettit) to the densities of Ca^+ and hydrogen, it is shown how their partial pressures are comparable with Milne's estimates for the pressure of Ca^+ in the chromosphere.

The question of the hydrogen content of prominences is of considerable importance, especially the question of the proportion of hydrogen to ionised calcium. Pannekoek and Doorn have found[1] that in their prominence "*a*" of the eclipse of 1927 the number of hydrogen atoms was $1{\cdot}6 \times 10^{11}$ per c.c. and of ionised calcium atoms only 0·13 per c.c.; in their prominence "*b*" the number of hydrogen atoms was 33×10^{11} per c.c. and of calcium atoms only 1·6 per c.c. In other words, they find the calcium content of prominences to be insignificant, the ratio of the number of hydrogen to calcium atoms being of the order of 2×10^{12}. Pettit has improved[2] upon their estimates of the densities by assuming a more reasonable shape, and hence a better value of the volume for either prominence, and by allowing for the comparative "weakness" of the prominences observed; but this leaves the proportion of hydrogen to calcium unchanged.

In Milne's theory of selective radiation pressure as the force supporting prominences, the radiation pressure can be effective only on Ca^+ atoms, that on other atoms being comparatively insignificant. A difficulty of this theory is to explain the presence of hydrogen and helium at all in prominences; Pannekoek and Doorn's estimate of the enormous excess of hydrogen in prominences increases the difficulty considerably and, indeed, if it were true, would be fatal to the theory of radiation pressure as the supporting force. For, if the prominence is supported by pressure on the calcium content alone, how are we to explain the presence of 2×10^{12} as many atoms of hydrogen? Even if we could find an explanation of how the lifting force acting on calcium atoms could be communicated to atoms of other elements (for instance, by collisions, "turbulence," or other means), we are unlikely to succeed in explaining in this way an enormous excess of hydrogen of the order of 2×10^{12} times.

(1) Verhand d. Koninklijke Akademie v.w.t. Amsterdam, etc., Deel 14, No. 2.
(2) Ap. J. 76, 1 P. 17 seq. (1932).

Now Pannekoek and Doorn's result depends on the factor which they have used for ascertaining the number of unexcited hydrogen atoms from the evaluated number of atoms in the fifth quantum state This factor they have taken as $\frac{1}{1\,2\times10^{-12}}$ by assuming that it would be the same as for a gas in thermodynamic equilibrium It is easily possible to show, without considering the observed intensities at all, that Pannekoek and Doorn's assumption of thermodynamic equilibrium must necessarily lead to a high density, much higher than that obtained when monochromatic radiative equilibrium holds, and further that, in conditions of line absorption and emission their high density leads to results which cannot possibly be true There appears to be little doubt that their high value for the hydrogen content of prominences is due to the unwarranted (though tentative) assumption of thermodynamic equilibrium to deduce the number of normal atoms

It should also be mentioned that Pannekoek and Doorn's deduced density of the "atoms in the fifth quantum state" relates in fact only to those atoms which fall from state *5* to state *2* thereby emitting $H\gamma$, the two aggregates are not identical[1], and it is not legitimate to infer from the density of the excited $H\gamma$ particles the density of atoms in state *1*

In this paper an attempt is made to calculate the hydrogen content of prominences using Pannekoek and Doorn's observational data but abandoning the assumption of thermodynamic equilibrium The results indicate an entirely different order of magnitude for the hydrogen content, but until more complete observations are available, it is not claimed that the results here derived do more than indicate the *order of magnitude*

2 The assumed similarity of the condition existing in a prominence to that of a gas in thermodynamic equilibrium is certainly opposed to Milne's views[2] of the solar atmosphere, according to which the state of local thermodynamic equilibrium in lower layers changes to one of monochromatic radiative equilibrium in the upper layers

If the matter were in local thermodynamic equilibrium, whatever the nature of the radiation incident on it, the radiation emitted will have a definite frequency-distribution, and the number of atoms emitting a particular frequency will bear a definite relation to the total number of atoms of the substance participating in the radiation, so that one may infer, as Pannekoek and Doorn did, the number of atoms in state *1* from the number of atoms in state *5* On the other hand, monochromatic radiative equilibrium involves a particular frequency being absorbed and re emitted without change of wavelength by an atom during transitions between two stationary states, the relative numbers of atoms in the two states bear a definite relation to each other, depending on the intensity of the incident radiation Whereas in the former case, the ratios depend on the temperature at the point and not at all on the incident radiation (which is accordingly redistributed before emission), in the latter case the ratios depend on the intensities of the several frequencies which are, in general, independent, so that there is no necessary relation between the atoms in the various quantum states of the substance in monochromatic radiative equilibrium, and one cannot infer the number of atoms in state *1* from that of atoms in state *5* emitting the frequency ν_{52}

Further, in monochromatic radiative equilibrium, the set of atoms in a particular quantum state, say state *5*, emitting a frequency ν_{52} is not, in general, co terminous with the total number of atoms in that state It is even possible to regard the atoms passing between states *5* and *2* absorbing and emitting $H\gamma$ as a statistical aggregate distinct from similar aggregates partaking in the radiations of other frequencies Even if a particular atom in state *5* passes to another state such as state *1*, the principle of detailed balancing requires that an atom should pass at once from state *1* to state *5*, and again another make the reverse of the first transition, viz, $5\rightarrow2$ It is not enough if the atom passing from state *5* to state *2* is replaced *somehow*, e g, by an atom passing from state *3*, the latter being replaced by an atom from state *1*, this would introduce a cycle of

(1) This is explained in greater detail in the following section
(2) Vide several papers in the Monthly Notices of the R A S A concise account appears in Handbuch d Astrophysik Bd III, I half, Chap 2

transitions, and there appears to be good reason to taboo cyclic processes.[1] Thus, for every atom passing from state *2* to state *5* there is another passing from state *5* to state *2*. Or, statistically regarded, these form a set of atoms making the reversible transition state $2 \rightleftarrows$ state *5*, absorbing and emitting ν_{25}.

If there are n_2 atoms in state *2*, of which the number $n_2\,(\nu_{25})$ are capable of absorbing the frequency ν_{25} and arriving at state *5*, the number of atoms which actually make this transition in time *dt*

$$= B_{25}.\ \ n_2\,(\nu_{25}).\ \left(\int I_{25}\frac{d\omega}{4\pi}\right).dt.$$

where B_{25} is the Einstein probability coefficient for the transition $2 \longrightarrow 5$ in the presence of isotropic radiation of intensity I_{25}. And the number passing from state *5* to state *2* is, by the principle of detailed balancing equal to this.

Similarly, the number leaving state *5* for any other state, say state *1* will be

$$= B_{15}.\ \ n_1\,(\nu_{15}).\ \left(\int I_{15}\frac{d\omega}{4\pi}\right).dt.$$

The coefficients B_{15}, B_{25}......are constants for the atom. The intensities I_{15}, I_{25}......have no known relations with one another, unless the matter be in local thermodynamic equilibrium. So that the number of atoms leaving state *5* for state *2* so as to emit Hγ is distinct from that of atoms leaving for state *1*, not to mention the total number of atoms in the fifth state. Hence it is easily seen that the number of atoms in the fifth state found from the intensity of Hγ-radiation can afford no clue to the total number of atoms in the lowest state, if we regard the conditions in the prominence to be the same as in the chromosphere. All that we can infer is the number of atoms in state *2*—the "normal state" for the Balmer lines—partaking in Hγ-radiation. In the same way the intensities of other Balmer lines may give the numbers of hydrogen atoms partaking in the radiation of the corresponding lines, $n_2\,(\nu_{23})$, $n_2\,(\nu_{24})$, etc. These sets of atoms are not in general coincident with the $n_2\,(\nu_{25})$ atoms absorbing ν_{25}: supposing that they do not partially overlap, the maximum number of atoms in state *2* is given by the sum of these separate numbers. Similarly we may find the number of atoms in state *1* if we knew the intensities of the Lyman lines.

3. The objection to the assumption of thermodynamic equilibrium may again be presented from other standpoints.

(*a*) Milne shows[2] that in any steady state, the equation of transfer of radiation can be expressed as

$$\frac{dI_\nu}{d\tau_\nu} = -I_\nu + \frac{\int I_\nu \frac{d\omega}{4\pi} + \eta B_\nu\,(T)}{1+\eta},$$

where *T* is a parameter corresponding to an assumed pseudo-Maxwellian distribution of velocities,

τ_ν is the optical depth for colour ν, and

η is the factor depending on the probability coefficients of transition by collision; it is independent of T, and varies as the density ρ:

$$\begin{cases} \eta \longrightarrow \infty & \text{as } \rho \longrightarrow \infty \\ \eta \longrightarrow 0 & \text{as } \rho \longrightarrow 0 \end{cases}$$

At high densities, $\eta \longrightarrow \infty$, and the equation takes the form

$$\frac{dI_\nu}{d\tau_\nu} = -I_\nu + B_\nu(T),$$

which is the equation of transfer for thermodynamic equilibrium. Thus he infers that the more the atoms are battered about by collisions, the more closely will emission correspond to the Kirchoff emission. No wonder then that Pannekoek and Doorn by assuming thermodynamic equilibrium arrived at high densities; in a sense the reasoning involves a vicious circle.

---

(1) Cf. Eddington; Internal constitution of stars, p. 45 seq.

(2) Op. cit. p. 163 seq.

Further, at low densities $\eta \longrightarrow o$, and the equation becomes

$$\frac{dI_\nu}{d\tau_\nu} = -I_\nu + \int I_\nu \frac{d\omega}{4\pi},$$

which is the form of the equation of transfer for monochromatic radiative equilibrium We may point out that the converse is easily seen to hold so that, if monochromatic radiative equilibrium were assumed instead of thermodynamic equilibrium, we should get only low values for the density

(*b*) That Pannekoek and Doorn's high value of density of atoms in the first state is inconsistent with conditions of line radiation can be shown in another way

If the number of atoms in state *1* be denoted by n_1 per c c the number of atoms that absorb the 4th Lyman line (say) in time dt

$$= n_1 \ B_{15}\left(\int I_\nu \frac{d\omega}{4\pi}\right) dt,$$

where $I\nu$ is the intensity of the incident radiation

The amount absorbed per sec per c c $= n_1 \ B_{15}\left(\int I_\nu \frac{d\omega}{4\pi}\right) h\nu_{15}$

This is a fraction s_ν of the radiation incident on unit volume

$$= s_\nu \int I_\nu \frac{d\omega}{4\pi},$$

the limits of integration being the same as before, for instance, in the case of isotropic radiation, the integration is carried over a complete sphere round an internal point so that the integral reduces to I_ν in either case, while at the boundary, the integration is confined to the lower hemisphere, and the integral becomes $\frac{1}{2} I_\nu$ —

$$n_1 B_{15} \ h\nu_{15} = s_\nu$$

$$\text{Also} \quad \frac{A_{51}}{B_{15}} = \frac{2h\nu_{15}^3}{c^2} \ \frac{q_1}{q_5}$$

$$\frac{q_1}{q_5} \ s_\nu = n_1 \ A_{51} \ \frac{c^2}{2\nu^2}$$

$$= n_1 \ A_{51} \ \tfrac{1}{2} \ \left(\frac{25}{24R}\right)^2$$

Using Pannekoek and Doorn's value for n_1 1 6 × 10^{11}, and Francis Slack's value(1) for $A_{51} = 412 \times 10^7$, in the right hand side we get

$$\frac{q_1}{q_5} s_\nu \sim 3 \times 10^7,$$

which is absurd, since the left-hand side is a proper fraction

(*c*) Pannekoek and Doorn make use of the Schrödinger-Pauli formula for intensities in terms of the series number and temperature—assuming thermodynamic equilibrium— in order to derive the temperature T from their observed values of the intensities for the 5 Balmer lines The curve plotted—log $I_l/\phi(l)$ against $1/l^2$ must be a straight line whose slope depends upon the temperature T But the attempt to fit a straight line to the plotted values cannot be claimed to be entirely successful—even allowing for the experimental errors mentioned the discrepancy is most glaring in the relative positions of the H_α and H_β. Though the authors suggest the various experimental defects as the cause of the high value of temperature obtained, the error may at least in equal (if not greater) probability, be due to their tentative assumption of thermodynamic equilibrium

4 We may now proceed to estimate the densities of hydrogen atoms in various states, on the assumption that conditions in prominences resemble the condition of the chromosphere, i e , a state of monochromatic radiative equilibrium

(1) Phys Rev 31, 527 (1928)—quoted by Caroll in M.N.R.A.S 90,590

Considering radiation of a particular colour, there will be some relation between the number of atoms in the "excited state" and that in the lower state. For matter in local thermodynamic equilibrium, this relation will depend on the temperature T at the point, and is given by Boltzmann's equation:

$$\frac{n_r}{n_s} = \frac{q_r . e^{-\chi_r/kT}}{q_s . e^{-\chi_s/kT}}$$

where n_r, q_r, χ_r represent the number of atoms per c.c., the "statistical weight," and the internal atomic energy corresponding to state r.

$$\therefore \frac{n_r}{n_s} = \frac{q_r}{q_s} . e^{(\chi_s-\chi_r)/kT}$$

$$= \frac{q_r}{q_s} . e^{h\nu/kT}$$

where ν is the frequency emitted when the atom passes from state s to state r.

As this formula depends on the temperature sheerly in virtue of the velocity-distributions, it may be taken to hold wherever there is a similar velocity-distribution.(1) Such may be assumed to be the state in monochromatic radiative equilibrium also. Though we cannot talk of a temperature T (since there is no thermodynamic equilibrium) yet there is a parameter T corresponding to the pseudo-Maxwellian distribution, which will behave just like the temperature T for all intents and purposes, inasmuch as a thermometer exposed to these velocities will receive such a number of collisions of varying magnitudes as will cause it to register a temperature T.

But this parameter T will in general vary with each colour, except in the case of local thermodynamic equilibrium; it is, in fact, measurable only from the observed intensities which, as stated above, have no fixed relations with one another, in a state of monochromatic radiative equilibrium.

For want of definite data, we assume $T = 5500°$ in the following calculations. This is not to mean that a uniform temperature is conceded in the case of the several radiations considered; on the contrary, 5500° is adopted as the parameter in the hope that it will be roughly of the same order of magnitude. Even so, this is radically different from the assumption of a uniform temperature for the complete continuum of frequencies such as exists in a state of thermodynamic equilibrium.

Thus, for the Balmer lines, ignoring statistical weights,

$$\frac{n_2}{n_r} = e^{hc/\lambda kT}, \quad \text{——— (1)}$$

where T may be taken as $\sim 5500°$.

Also, the emission by the atoms in the rth state per c.c.

$$= n_r . A_{r2} . h\nu_{r2} . \text{ ergs per sec. ——— (2)}$$

Denoting by E_ν the intensities given by Pannekoek and Doorn, and the volume of the prominence by V, the emission per c.c. $= \frac{E_\nu}{V}$. From this and (2), we get

$$n_r = \frac{E_\nu}{V} . \frac{\lambda}{hc} . \frac{1}{A_{r2}} \quad \text{——— (3)}$$

Using Pannekoek and Doorn's value of the volume of prominence "a" as $5{\cdot}8 \times 10^{29}$ c.c. and their intensity-values for the different images (see column *5* of the following table), and Francis Slack's values(2) (column *4*) for the probability co-efficients A_{r2}, n_r can be calculated (column *6*). And from this the values of n_2 can be known with the aid of equation (1) (column *7*). The number of atoms $(n_2 + n_1)$ taking part in the radiation of each line is given in the last column of the table. Assuming that there is no overlapping,

(1) In this argument, I follow Milne: Op. cit. p. 160.

(2) Loc. cit.

the total number of atoms partaking in the radiation of the Balmer lines is obtained by adding up these numbers $\Sigma(n_2 + n_r)$

r	Line	Wavelength A U	Transition probability A_{r2}	Intensities erg/sec E_ν	Number of atoms in excited state, n_r	Number of atoms in second state, n_2	Number of atoms $n_2 + n_r$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
3	$H\alpha$	6563	$4\ 42 \times 10^7$	1890×10^{22}	0 246	13 028	13 27
4	$H\beta$	4861	845	512	0 258	54·813	55·07
5	$H\gamma$	4341	254	126	0 189	76 130	76 42
6	$H\delta$	4102	102	115	0 406	231 910	232 32
7	$H\xi$	3890	046	18 8	0 139	112 680	112 82
						Total	489 90

The number of atoms in state *2* is found to be increasing as we pass from $H\alpha$ to $H\delta$, because A_{r2} decreases much more rapidly than the observed intensities In this connexion we have to bear in mind the uncertainties in the measures of the intensities which, in the words of the authors, [1] are "caused by the great density of the prominence images, the extrapolation from the density curves, and the large influence of the Schwarzschild exponent", these factors obviously make the error greater, the denser the image, so that the values of n_2 are probably more and more reduced as we go from $H\delta$ to $H\alpha$ It is satisfactory to note, however, that the number begins to decrease as we come to $H\xi$, and perhaps one may conjecture that it will continue to decrease as we go to other members of the series The total number of atoms partaking in the radiation of the Balmer lines may therefore be taken as of the order of *500* Taking account of the facts that the different sets of (n_2) atoms found above may overlap to some extent, and that the statistical weights will tend to reduce these numbers, we may safely put *500* as the *maximum* number of atoms

The number of atoms in state *1* can be found as argued above, only from a knowledge of the intensities of the Lyman lines The ratio used by Pannekoek and Doorn $(1\ 20 \times 10^{-12})$ is really the ratio $n_2(\nu_{15}) : n_1(\nu_{15})$, $n_2(\nu_{15})$ can be found only if the intensity $I(\nu_{15})$ were known The intensities of the Lyman lines in prominence spectra are not known, but if the intensity $I(\nu_{15})$ were $\sim 10^{-9}$ times that of $H\gamma$, we get the same order of magnitude for the density of atoms in state *1* absorbing and emitting the first Lyman line, for that of the $H\gamma$ particles

We arrive at the same result from calculations similar to that made in a previous section (3 c)

Since the fraction $\frac{q_1}{q_2}\ s_\nu < \frac{1}{25}$, we get $n_1 < 2\ 2 \times 10^2$

Thus we may estimate the number of hydrogen atoms per c c in the prominence to be at most of the order of *1,000* This produces a pressure of about $7\ 5 \times 10^{-16}$ atmospheres, taking a temperature of 5500° Or if, with Pettit [2], we regard Pannekoek and Doorn's estimate of the volume of the prominence as 20 times too large, the pressure becomes $1\ 5 \times 10^{-14}$ atoms again, following Pettit in considering that, since the prominence "*a*" is comparatively "weak," the intensities of lines will be about six times as great in a "representative prominence" such as the prominence "c" of Pannekoek and Doorn, the partial pressure of hydrogen becomes 9×10^{-14} or slightly less than 10^{-13} atmospheres

5 The above estimate of the pressure of hydrogen is comparable with Milne's estimate of the pressure of Ca^+ at the top of the chromosphere [3], viz, $\sim 10^{-13}$ atmospheres Pannekoek and Doorn obtain as low a pressure for Ca^+ as $9\ 6 \times 10^{-20}$ atmospheres; but it appears to me that this low estimate is due to an error similar to that in the case of hydrogen

From Zwann's evaluation of the probability co-efficient $A_{42 \rightarrow 41}$ for the transitions 2S—2P, and 2S—2P, (H and K lines) combined as $1\ 55 \times 10^8$, they infer that each atom of Ca^+ emits $1\ 55 \times 10^8 \times h\nu = 7\ 69 \times 10^{-4}$ erg/sec But certainly, this is the amount emitted by each atom of Ca^+ in state *2*, and not the average amount

(1) Pannekoek and Doorn Op cit p 22 (2) Loc cit
(3) Cf Monthly Notices of the R A S 88, 193 (1928)

emitted by each atom of Ca^+. By regarding $7{\cdot}69 \times 10^{-4}$ erg/sec. as emitted by each Ca^+ atom, they obtain from their value of the total emission of H and K radiation by prominence " a " as $6{\cdot}03 \times 10^{25}$, the total number of Ca^+ atoms as $7{\cdot}8 \times 10^{28}$ or ·13 per c.c. But it is obvious that this is only the number of atoms in the excited state (n_2).

The number of atoms in the lower state (n_1) is given as before by the equation

$$\frac{n_1}{n_2} = \frac{q_1}{q_2} \cdot e^{hc/\lambda kT}, \quad (\lambda = 3950 \text{Å.U.})$$

$$= 7{\cdot}30 \times 10^2 \text{ (omitting statistical weights).}$$

$$\therefore n_1 = {\cdot}13 \times 730 = 94{\cdot}9.$$

$$n_1 + n_2 = 95{\cdot}03.$$

The pressure due to $n_1 = 730$ times the pressure due to n_2.

$\therefore$ The pressure of Ca^+ atoms $= 731 \times 9{\cdot}6 \times 10^{-20}$

$$\sim 7{\cdot}02 \times 10^{-17} \text{ atmospheres.}$$

Correcting, as in the case of hydrogen, for the excess of the assumed volume and the weakness of the lines, the partial pressure of Ca^+ atoms in a "representative prominence."

$$= 6 \times 20 \times 7{\cdot}02 \times 10^{-17}$$

$$\sim 8{\cdot}4 \times 10^{-15} \text{ atmospheres.}$$

Thus the partial pressure of Ca^+ atoms is $\frac{1}{10}$ of that of hydrogen. The hydrogen content, as measured by its mass, will be only $\frac{1}{4}$ of that of Ca^+.

6. *Conclusion.*—We may therefore conclude that, if we do not assume a state of thermodynamic equilibrium in the prominences, the density of the hydrogen is no longer of immense proportions ; on the other hand, it is comparable with the density of Ca^+ in the prominences and, what is more, both these values agree closely with Milne's estimates of the density of Ca^+ at the top of the chromosphere. We can be more certain of the estimates of hydrogen-content of prominences, only if we know the intensities of other series of hydrogen lines, especially the first few Lyman lines. If these intensities should happen to be large, the density of hydrogen atoms in the first state will be preponderatingly large, and the condition in the prominence will approximate to one of thermodynamic equilibrium ; if, on the contrary, these intensities should be very low—as we imagine them to be—then the densities will be low as stated above and the condition approximate to one of monochromatic radiative equilibrium. What exactly is the condition existing in the prominence cannot at present be known for certain. Nevertheless one may hazard the conjecture, in the light of Milne's theory and the experience of hydrogen images being less dense than ionised calcium images, that the conditions in prominences correspond more to those in the upper layers of the sun's atmosphere than in the lower layers, that is, to monochromatic radiative equilibrium rather than thermodynamic equilibrium, to lower densities of the gases rather than high, and to lower densities of hydrogen than of calcium.

I wish to express my sense of gratitude to Dr. T. Royds for kindly suggesting the above problem to me for investigation and for the valuable criticism and assistance he afforded me in preparing this paper.

KODAIKANAL OBSERVATORY,
14*th June* 1933.

C. P. S. MENON,
Research Fellow of the University of Madras.

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Kodaikanal Observatory.

BULLETIN No. CII.

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE SECOND HALF OF THE YEAR 1932.

In pursuance of the programme of work adopted since 1st January 1923 under the auspices of the International Astronomical Union, all observatories taking spectroheliograms of the sun have been asked to co-operate with the Kodaikanal Observatory by supplying copies of their photographs on those days when the Kodaikanal records are imperfect or wanting. In response to our requirements for the second half of the year 1932, the Mount Wilson Observatory supplied calcium (K_{23}) prominence plates for 55 days, Hα disc plates for 37 days and the Meudon Observatory supplied calcium (K_3) disc plates for 6 days and Hα disc plates for 36 days.

When only incomplete or imperfect photographs for any day are available from more than one observatory, the best photograph is chosen as representing the solar activity of that day, after weighting it according to its quality, and the remaining photographs are ignored.

Calcium Prominences at the Limb.—The mean daily areas and numbers of prominences photographed during the half-year by means of the K line of calcium are given below. The means are corrected for incomplete or imperfect observations, the total of 178 days for which plates were available being reduced to 165 effective days.

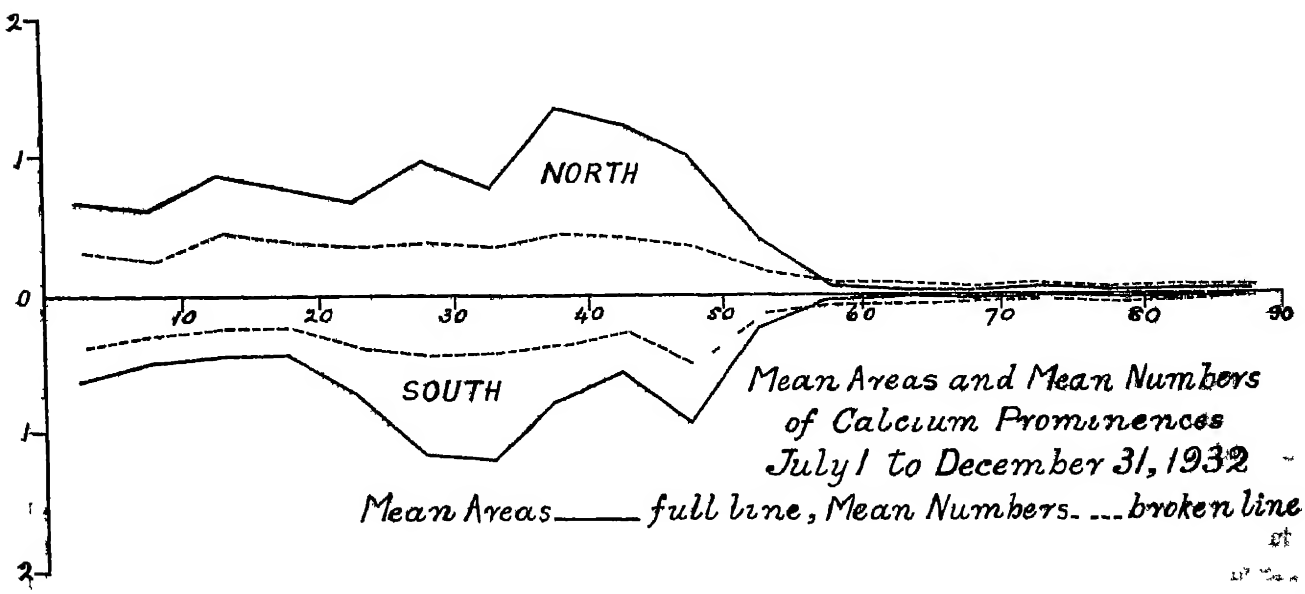
	Mean daily areas (square minutes).	Mean daily numbers.
North	0·96	4·34
South	0·77	4·07
Total ...	1·73	8·41

Compared with the previous half-year, areas and numbers show a decrease of 33 per cent and 22 per cent, respectively.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 143 days of observation being counted as 122½ effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North (Kodaikanal photographs only)	0·98	4·50
South (do.)	0·77	4·24
Total ...	1·75	8·74

The distribution of prominences in latitude is represented in the following diagram, in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude The ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line Compared with the previous half year, the distribution of activity exhibits some well marked differences The peak near 30° N which was seen in the first half of the year has now disappeared from the northern hemisphere and is evidenced in the southern hemisphere where the activity near 45° has been much reduced



The monthly, quarterly and half-yearly areas and numbers and the mean height and mean extent of the prominences on photographs from all co operating observatories are given in Table I The unit of area is 1 square minute of arc The mean height is derived by adding together the greatest heights reached by individual prominences and dividing by the total number of prominences observed, the mean extent is derived by adding together the lengths of the base on the chromosphere of individual prominences and dividing by the total number of prominences —

TABLE I—ABSTRACT FOR THE SECOND HALF OF 1932

Months, 1932	Number of days (effective).	Areas	Numbers	Daily means Areas	Daily means Numbers	Mean height ″	Mean extent °
July	29	53 3	262	1 8	9 0	30 4	3 59
August	28	45 2	213	1 6	7 6	35 1	4 37
September	29¼	50 6	230	1 7	8 0	35 1	3 33
October	28¼	46 4	220	1 6	7 8	33 8	3 59
November	25¾	41 0	216	1 6	8 4	33 7	3 06
December	24¾	48 3	244	2 0	9 8	32 3	3 32
Third quarter	86¼	149 1	705	1 7	8 2	33 4	3 74
Fourth quarter	78¾	135 7	680	1 7	8 6	33 3	3 32
Second half year	165	284 8	1,385	1 7	8 4	33 3	3 54

Distribution East and West of the Sun's Axis.—Compared with the previous half-year, areas showed a slight defect and numbers an excess at the east limb as will be seen from the following table :—

1932 July to December.	East.	West.	Percentage East.
Total number observed	698	687	50·40
Total areas in square minutes	140·2	144·6	49·24

Hydrogen Prominences at the Limb.—During the half-year, photographs of the prominences in hydrogen light were taken at this observatory on 101 days which were counted as 75 effective days. The mean daily areas of hydrogen prominences in square minutes of arc, are given below :—

	Mean daily areas (square minutes).
North	0·36
South	0·26
Total ...	0·62

Compared with the previous half-year, Hα prominence areas show a decrease of 39 per cent. The ratio of Hα areas to calcium areas is 35 per cent. The curve of Hα prominences is intermediate between those of calcium prominences and Hα absorption markings.

Metallic Prominences.—There were no metallic prominences observed during the half-year.

Displacements of the Hydrogen Line.—Particulars of the displacements observed in the chromosphere and prominences are given in the following table :—

TABLE II.—DISPLACEMENT~~S~~ OF the HYDROGEN LINE~~S~~.

Date.		Time I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1932.		H.	M.	°	°		A.	A.	A.	
July	27	9	57		2	E		Slight		At top.
	28	9	53		25	W		0·5		
August	13	8	40		47·5	E		0·5		At top.
	14	9	25	83		E	0·5			In chromosphere.
	15	10	13		26	E		Slight		Do.
	25	8	10	24·5		E	1·5			At top.
		8	04		24	W		0·5		In chromosphere.
September	15	8	47	52·5		W	0·5			Do.
	21	8	35	80		W	0·5			At top.
	23	8	30		62	W	0·5			Do.
		8	20		2	W		1		At base.
	24	8	40		78·5	W		1		At top.
October	20	9	45	2		W	1·5			Do.
November	9	11	15		80	E	1			Do.
	16	9	0		77·5	E		Slight		Do.
	17	8	58		33	E		1		Do.
	30	9	56	31		W	0·5			Do.
December	5	9	02	48·5		E		0·5		Do.
		9	07	21·5		E	1			In chromosphere.
	8	9	08	58		E	0·5			At base.
	18	8	55	14·5		W	2			At top. Displaced 2·5 A to Red at 9^h 15^m.
	21	9	20	8		W	Slight			At top.
	27	8	39		28	W	0·5			In chromosphere.
	28	9	16		7	E		0·5		At top.
		9	27	15		W	1			At top. Extends over 2° from + 14° to + 16°.

The total number of displacements was 25 as against 80 in the previous half-year and their distribution was as follows —

		North	South
1°—30°		6	7
31°—60°		4	2
61°—90°		2	4
	Total	12	13

East limb		12
West limb		13
	Total	25

Of the displacements, 14 were towards the red and 11 towards the violet

Reversals and Displacements on the Sun's Disc—Twenty-three bright reversals of the Hα line, 28 dark reversals of the D_3 line and 1 displacement of the Hα line were observed during the half-year Their distribution is given below —

	North	South	East	West
Bright reversals of Hα	16	7	11	12
Dark reversals of D_3	15	8	12	11
Displacements of Hα	1		1	

The one displacement observed was towards the red

Prominences projected on the Disc as Absorption Markings—Photographs of the sun's disc in Hα light were available from Kodaikanal and the co-operating observatories for a total of 176 days, which were counted as 163 effective days The mean daily areas of Hα absorption markings (corrected for foreshortening) in millionths of the sun's visible hemisphere and their mean daily numbers are given below —

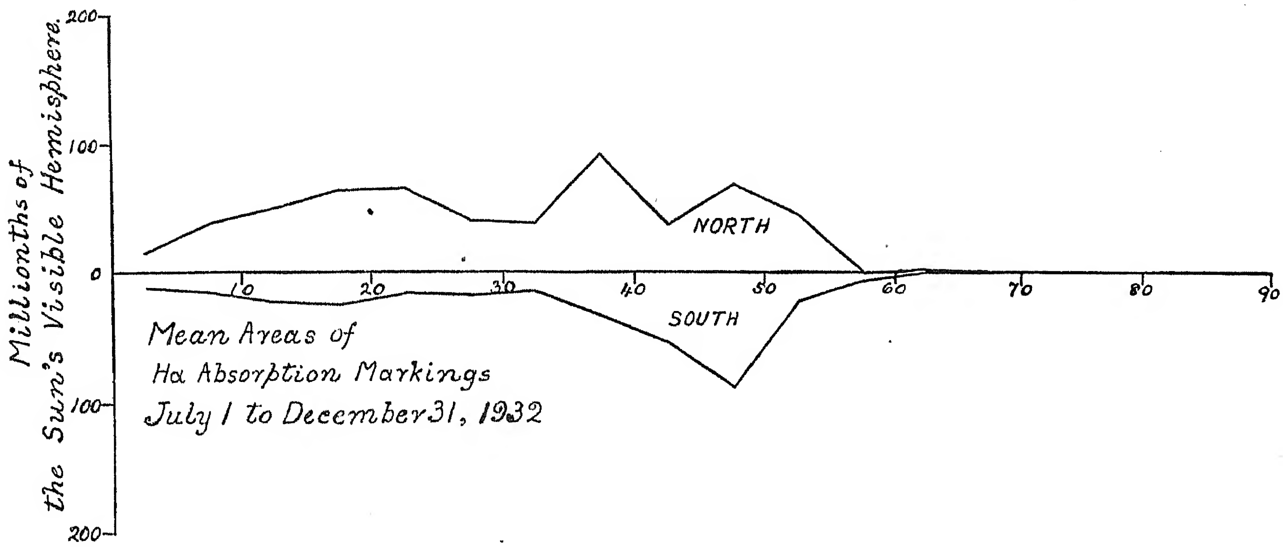
		Mean daily areas	Mean daily numbers
North		553	3 88
South		335	2 48
	Total	888	6 36

The above show a decrease of 48 per cent in areas and 41 per cent in numbers, compared with the previous half-year

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 120 days of observation being reckoned as 99 effective days,

		Mean daily areas	Mean daily numbers
North (Kodaikanal photographs only)		589	3 95
Do do		292	2 17
	Total	881	6 12

The distribution of the mean daily areas in latitude is shown in the following diagram. The high latitude peak in the southern hemisphere is much reduced, while that in the belt 40°—45° in the northern hemisphere has shifted 5° towards the equator.



Both areas and numbers show an eastern preponderance, the percentage east being 54 and 51, respectively, for areas and numbers. The areas of Hα absorption markings uncorrected for foreshortening are given below :—

	Mean daily areas.
North	325
South	168
Total ...	493

The uncorrected areas amount to 56 per cent of the corrected ones as against 51 per cent for the previous half-year.

The curve of distribution in latitude is similar to that for the corrected areas as usual.

Thanks are due to the co-operating observatories for the photographs supplied by them.

KODAIKANAL,
13th September 1933.

T. ROYDS,
Director, Kodaikanal Observatory.

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BULLETIN No. CIII.

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE FIRST HALF OF THE YEAR 1933.

In pursuance of the programme of work adopted since 1st January 1923 under the auspices of the International Astronomical Union, all observatories taking spectroheliograms of the sun have been asked to co-operate with the Kodaikanal Observatory by supplying copies of their photographs for those days when the Kodaikanal records are imperfect or wanting. In response to our requirements for the first half of the year 1933, the Mount Wilson Observatory supplied calcium (K_{23}) prominence plates for 25 days, Hα disc plates for 5 days and the Meudon Observatory supplied calcium (K_3) disc plates for 7 days and Hα disc plates for 30 days.

When only incomplete or imperfect photographs for any day are available from more than one observatory, the best photograph is chosen as representing the solar activity of that day, after weighting it according to its quality, and the remaining photographs are ignored.

Calcium Prominences at the Limb.—The mean daily areas and numbers of prominences photographed during the half-year by means of the K line of calcium are given below. The means are corrected for incomplete or imperfect observations, the total of 180 days for which plates were available being reduced to 167 effective days.

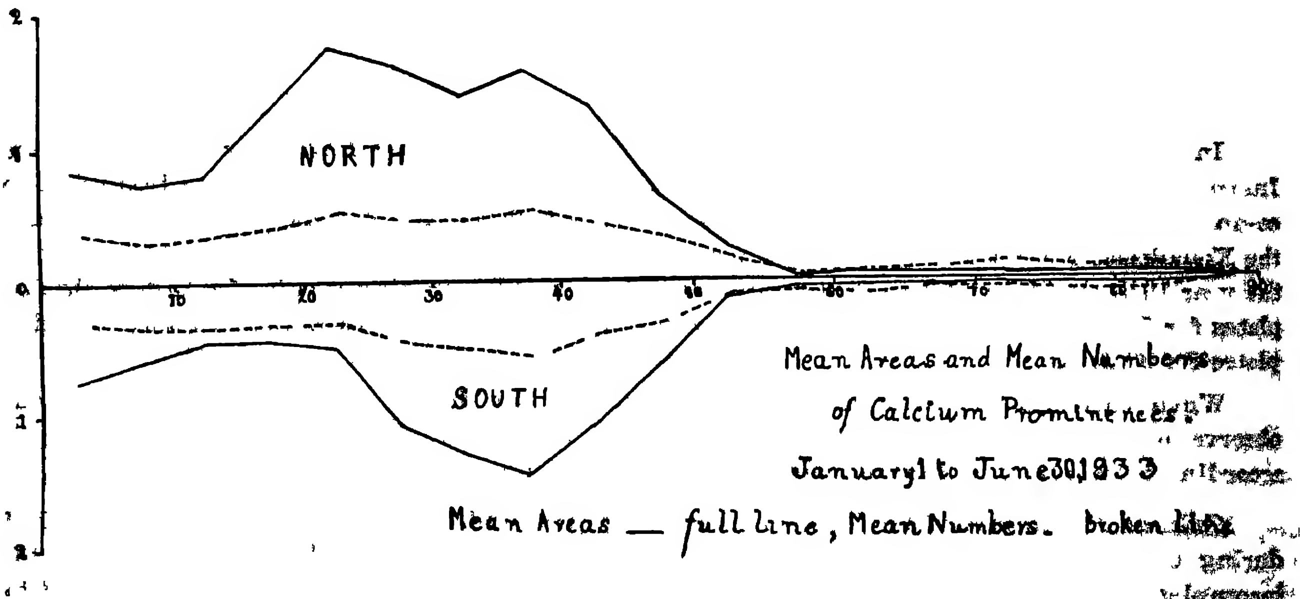
	Mean daily areas (square minutes).	Mean daily numbers.
North	1·25	4·92
South	0·83	4·29
Total ...	2·08	9·21

Compared with the previous half-year, areas and numbers show an increase of 20 per cent and 10 per cent, respectively.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 166 days of observation being counted as 148½ effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North (Kodaikanal photographs only)	1·28	5·07
South (do.)	0·89	4·50
Total ...	2·17	9·57

The distribution of prominences in latitude is represented in the following diagram, in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude. The ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line Compared with the previous half year there has been an increase of activity in the northern hemisphere near 20°, and in the southern hemisphere near 40°



The monthly, quarterly and half-yearly areas and numbers and the mean height and mean extent of the prominences on photographs from all co-operating observatories are given in Table I The unit of area is 1 square minute of arc The mean height is derived by adding together the greatest heights reached by individual prominences and dividing by the total number of prominences observed, the mean extent is derived by adding together the lengths of the base on the chromosphere of individual prominences and dividing by the total number of prominences —

Table I.—Abstract for the First Half of 1933

Months 1933	Number of days (effective)	Areas	Numbers	Daily means Areas	Daily means Numbers	Mean height ″	Mean extent °
January	28	57·7	262	2·1	9·4	41·6	4·74
February	27¼	46·3	265	1·7	9·7	34·4	4·36
March	30¼	58·3	290	1·9	9·6	35·6	4·70
April	27¾	74·1	266	2·7	9·7	40·9	4·36
May	26¾	48·7	222	1·8	8·3	36·5	4·64
June	27	62·1	232	2·3	8·6	43·2	5·11
First quarter	85½	162·3	817	1·9	9·6	37·1	4·60
Second quarter	81½	184·9	720	2·3	8·8	39·3	4·69
First half	167	347·2	1,537	2·1	9·2	38·2	4·64

Distribution East and West of the Sun's Axis.—As in the previous half-year, areas show a slight defect and numbers an excess at the east limb as will be seen from the following table :—

1933 January to June.	East.	West.	Percentage East.
Total number observed	790	747	51·40
Total areas in square minutes	171·2	176·0	49·30

Hydrogen Prominences at the Limb.—During the half-year, photographs of the prominences in hydrogen light were taken at this observatory on 157 days which were counted as 141 effective days. The mean daily areas of hydrogen prominences in square minutes of arc are given below :—

	Mean daily areas (square minutes).
North	0·64
South	0·45
Total ...	1·09

Compared with the previous half-year, Hα prominence areas show an increase of 76 per cent. The ratio of Hα areas to calcium areas is 52 per cent, a considerable increase over the previous half-year. The curve of Hα prominences is intermediate between those of calcium prominences and Hα absorption markings.

Metallic Prominences.—Three metallic prominences were observed during the half-year. The details are given below :—

TABLE II.—LIST OF METALLIC PROMINENCES.

Date.	Time I.S.T.	Base.	Latitude. North.	Latitude. South.	Limb.	Height.	Lines.
1933.	H. M.	°	°	°		″	
January 2 ...	8 50	1	8·5		W	35	4924·1, 5016, b_4, b_3, b_2, b_1, 5234·8, 5316·8, D_2, D_1, and 6677.
3 ...	9 35	1	9·5		E	10	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5234·8, 5276·2, 5316·8, 5363·0, D_2, D_1, 6677 and 7065.
14 ...	9 59	3	...	9·5	W	15	4924·1, 5016, 5018·6, b_4, b_3, b_2, b_1, 5197·5, 5206·2, 5208·7, 5234·8, 5269·7, 5270·6, 5276·2, 5284·3, 5316·8, 5336·9, 5363·0, D_2, D_1 and 6677.

Displacements of the Hydrogen Line.—Particulars of the displacements observed in the chromosphere and prominences are given in the following table :—

TABLE III.—DISPLACEMENTS OF THE HYDROGEN LINE.

Date.		Time I.S.T.	Latitude. North.	Latitude. South.	Limb.	Displacement. Red.	Displacement. Violet.	Displacement. Both ways.	Remarks.
1933.		H. M.	°	°		A.	A.	A.	
January	1	8 55		18·0	W	0·5			In chromosphere.
	2	9 02	46·0		E	0·5			Do.
		8 50	8·5		W	1·0			At top.
	3	9 14		48·0	E		Slight		Do.
	4	11 17	86·0		W			1·0	To violet at top and to red at base.
	13	9 08		42·0	E	0·5			In chromosphere.
	14	10 06		42·0	W	...	1·0	...	At top.
		9 38	8·0		W	1·0			Do.
		9 31	8·0	...	W	...	1·0	...	At base.
		9 31	11·0		W		0·5		Do.
	22	8 28	38·0	...	W	0·5		...	At top.
	26	9 15	3·0		E		1·0		At base.
	30	9 05	28·0		E	0·5			At top.
		8 55		16·0	W	Slight			In chromosphere.

TABLE III —DISPLACEMENTS OF THE HYDROGEN LINE—*cont*

Date		T m I S T	L tutud N rth.	S th.	Lımb	D splac ment Red	V ol t	B th w ys	R marks
1933		H M				A.	A	A	
F bruary	1	10 51	15 0		E		Sl ght		At top
		10 57	15 0		E			6 0	D
	2	9 18	15 0		E	0 5			At bas
		9 19	12 0		E		1 0		At top
		9 03	1 0		W	0 5			D
	4	11 17	7 5		W	0 5			D
	6	8 45	34 5		W	0 5			In chr m spher
	8	8 59	63 5		W	0·5			D
	10	9 19		14 0	W	0 5			At top
	12	9 16	1·0		W		Sl ght		In ch m spher
	13	9 10	9 5		W	1 0			At top
	17	8 45	13 0		W	1 0			Do
		8 38	49 5		W	Sl ght			In hr mosph
	18	8 51	70 5		W	0 5			D
	20	9 39	56 5		W		Slıght		D
	21	8 58	78 5		W	0 5			D
	22	9 40		41 5	E	Slıght			D
		9 57	75 5		W	2 0			At top
	23	9 12	21 0		E	0·5			At bas
	25	9 18	48 0		E	1 5			At top
	26	8 35	53 5		W	0·5			Do
March	1	9 13	35 5		W	1 0			At top
	4	9 19		12 5	E	0·5			D
	5	9 14	75 5		E	Slıght			D
	6	9 30		13 5	W	Sl ght			At bas
	7	8 48		37 5	W	0 5			At top
	17	9 07		40 5	E	0 5			D
		8 51	66 0		W	0 5			I chrom sph re
	19	8 50		83 0	E	0 5			At t p
	20	9 24	66 0		W		Slıght		I chr mo phere
	25	10 47	23 0		E	Sl ght			D
		10 51	8 0		E		2 5		At top E t nd fr m 7 to 9°
		10 51	5 0		E	1 5			At bas Extends from 4 to 6°
Apríl	3	9 3		14·0	E		1·0		At top
	7	9 10		53 5	E		0 5		In chr mosphere
		8 55	39·5		W	0 5			At t p
	12	8 49		6·0	E	0 5			At b e
		8 50		12·0	E		0 5		D
	13	11 15		78 5	E	0 5			I chromo ph e
	18	8 48		21 0	W		Slıght		Do
	21	8 48	17 0		W	Slıght			D
	24	9 04	76 0		E		0 5		D
	28	9 11	44 0		E		0 5		At top
		9 12	35 0		E		1 0		D
	30	8 50	12 5		W	1 5			Do
M y	10	9 08	32 0		E	0 5			At top
		9 30	16 0		E		0 5		At base
		9 21	38 0		W	1 0			At top Extends from 37 — 39°
Jun	8	10 12		20 0	E		1 0		At top
	14	8 58		40·0	E		Slıght		Do

The total number of displacements was 64 as against 25 ın the prevıous half year and their distribution was as follows —

	North	South
1 —30°	22	10
31 —60	13	8
61 —90°	9	2
Total	44	20

East limb	31
West limb	33
Total ...	64

Of these displacements 41were towards the red, 21 towards the violet and 2 both ways simultaneously.

Reversals and Displacements on the Sun's Disc.—Seventy-seven bright reversals of the Hα line, 67 dark reversals of the D_3 line and 3 displacements of the Hα line were observed during the half-year. Their distribution is given below:—

	North.	South.	East.	West.
Bright reversals of Hα	77	...	34	43
Dark reversals of D_3	67	...	31	36
Displacements of Hα	3	...	1	2

Two displacements were towards the red and one towards the violet.

Prominences projected on the Disc as Absorption Markings.—Photographs of the sun's disc in Hα light were available from Kodaikanal and the co-operating observatories for a total of 180 days, which were counted as 175¼ effective days. The mean daily areas of Hα absorption markings (corrected for foreshortening) in millionths of the sun's visible hemisphere and their mean daily numbers are given below:—

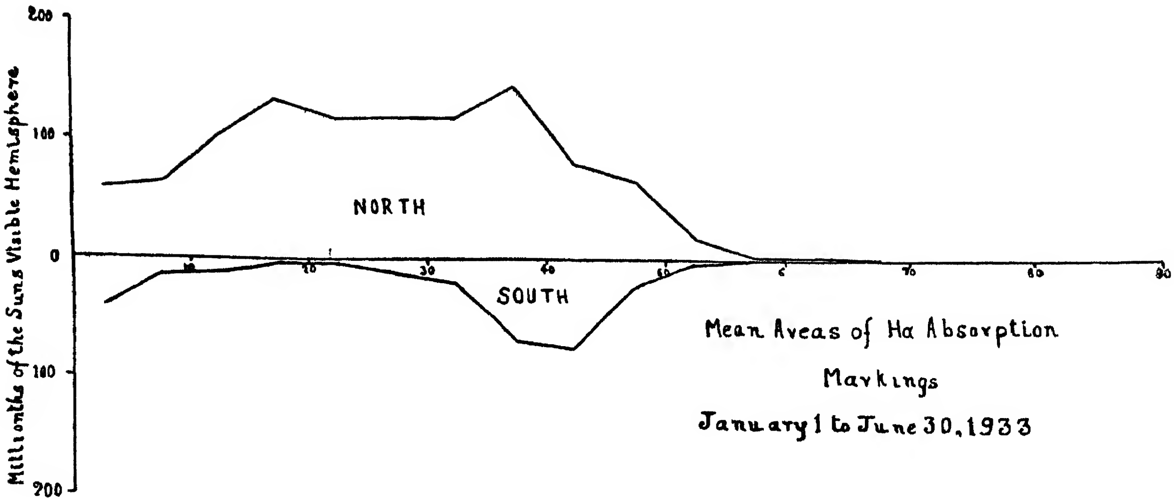
	Mean daily areas.	Mean daily numbers.
North	995	6·34
South	292	2·20
Total ...	1,287	8·54

The above show an increase of 46 per cent in areas and 40 per cent in numbers, compared with the previous half-year.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 157 days of observation being reckoned as 149¼ effective days.

	Mean daily areas.	Mean daily numbers.
North (Kodaikanal photographs only)	945	5·96
South (Do. do.)	281	2·14
Total ...	1,226	8·10

The distribution of the mean daily areas in latitude is shown in the following diagram. The distribution is almost uniform in the northern hemisphere. Compared with the previous half-year there is, in the northern hemisphere, an increase in all latitudes up to 50°, whilst in the southern hemisphere there is a notable increase in the belt 0°—5°.



As in the previous half year, both areas and numbers show an eastern preponderance, the percentage for both being 51 The areas of Hα absorption markings uncorrected for foreshortening are given below —

	Mean daily areas
North	539
South	164
Total	703

The uncorrected areas amount to 55 per cent of the corrected ones, almost the same as for the previous half-year

The curve of distribution in latitude is similar to that for the corrected areas as usual

Thanks are due to the co operating observatories for the photographs supplied by them

KODAIKANAL,
20th January 1934

T ROYDS,
Director, Kodaikanal Observatory

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Kodaikanal Observatory.

BULLETIN No. CIV.

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE SECOND HALF OF THE YEAR 1933.

In pursuance of the programme of work adopted since 1st January 1923 under the auspices of the International Astronomical Union, all observatories taking spectroheliograms of the sun have been asked to co-operate with the Kodaikanal Observatory by supplying copies of their photographs for those days when the Kodaikanal records are imperfect or wanting. In response to our requirements for the second half of the year 1933, the Mount Wilson Observatory supplied calcium (K_{23}) prominence plates for 50 days and Hα disc plates for 28 days the Meudon Observatory supplied calcium (K_3) disc plates for 7 days and Hα disc plates for 45 days, and the Pitch Hill Observatory, Ewhurst (Mr. J. Evershed's), supplied Hα disc plates for 7 days.

When only incomplete or imperfect photographs for any day are available from more than one observatory, the best photograph is chosen as representing the solar activity of that day, after weighting it according to its quality, and the remaining photographs are ignored.

Calcium Prominences at the Limb.—The mean daily areas and numbers of prominences photographed during the half-year by means of the K line of calcium are given below. The means are corrected for incomplete or imperfect observations, the total of 182 days for which plates were available being reduced to 161½ effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North	1·38	4·49
South	0·89	3·73
Total	2·27	8·22

Compared with the previous half-year, areas show an increase of 9 per cent. mainly in the northern hemisphere, and numbers a decrease of 11 per cent.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 137 days of observation being counted as 110 effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North (Kodaikanal photographs only)	1·47	4·65
South Do.	0·99	4·13
Total	2·46	8·78

The distribution of prominences in latitude is represented in the following diagram, in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude. The ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line. Comparing the distribution of prominence areas with the previous half-year there has been increased activity in the belt

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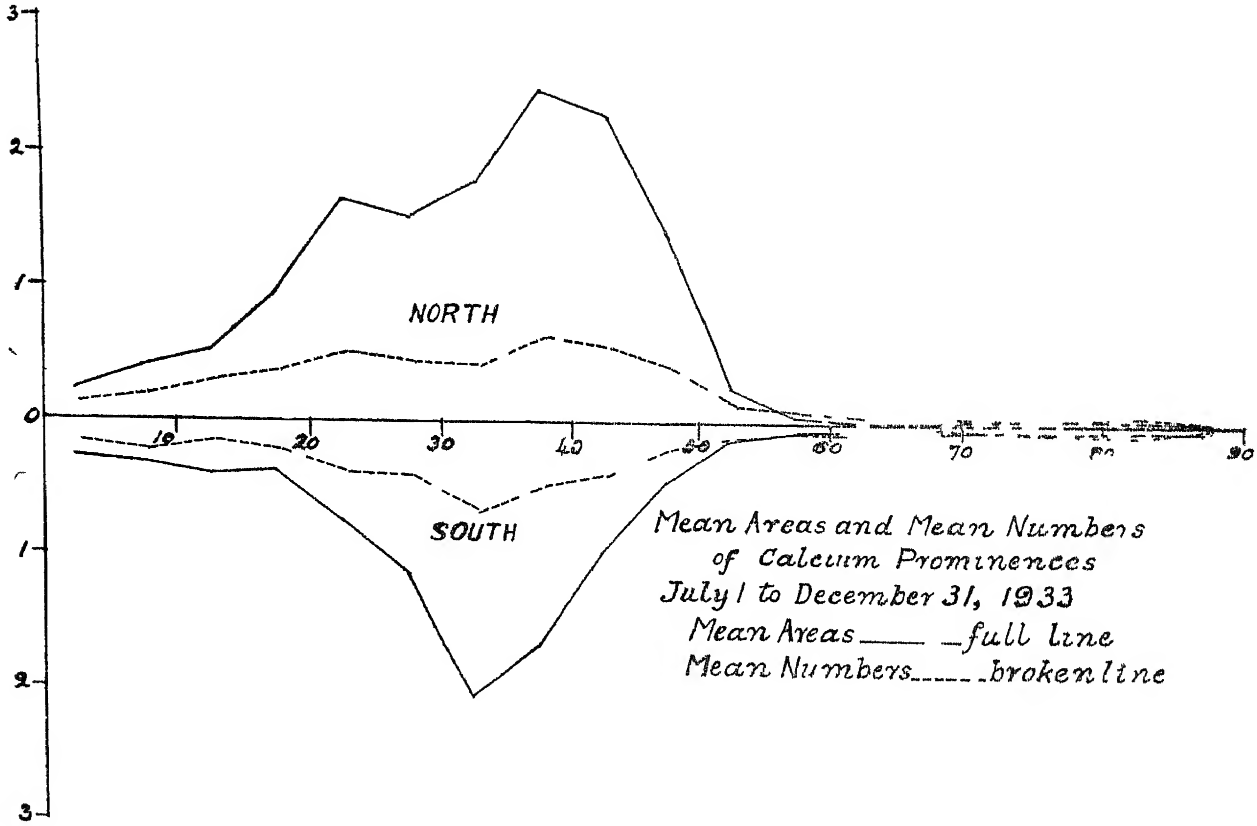
30°—50° in the northern hemisphere and in the belt 30°—40° in the southern, and decreased activity near the equator, the maximum activity is near 35° in both hemispheres Prominence areas are again considerably greater in the northern hemisphere than in the southern



The monthly, quarterly and half yearly areas and numbers and the mean height and mean extent of the prominences on photographs from all co operating observatories are given in Table 1 The unit of area is 1 square minute of arc The mean height is derived by adding together the greatest heights reached by individual prominences and dividing by the total number of prominences observed the mean extent is derived by adding together the lengths of the base on the chromosphere of individual prominences and dividing by the total number of prominences

TABLE I —ABSTRACT FOR THE SECOND HALF OF 1933

Months 1933	Number of days (effective)	Areas	Numbers	Daily means Areas	Daily means Numbers	Mean height	Mean extent
						′	°
July	28¼	71.9	238	2.5	8.4	42.3	4.61
August	28¼	54.2	243	1.9	8.6	40.1	3.86
September	26¾	60.9	225	2.3	8.4	41.4	4.00
October	24¼	50.2	188	2.1	7.8	39.0	4.52
November	25¼	64.9	209	2.6	8.3	41.3	4.11
December	28¾	63.6	224	2.2	7.8	38.1	4.75
3rd quarter	83¼	187.0	706	2.2	8.5	41.2	4.16
4th quarter	78¼	178.7	621	2.3	7.9	39.5	4.47
2nd half year	161½	365.7	1 327	2.3	8.2	40.4	4.30

Distribution East and West of the Sun's Axis.—Areas showed a considerable defect and numbers a slight defect at the east limb as will be seen from the following table :—

1933 July to December.	East.	West.	Percentage East.
Total number observed	651	676	49·06
Total areas in square minutes . . .	166·8	198·9	45·61

Hydrogen Prominences at the Limb.—During the half-year, photographs of the prominences in hydrogen light were taken in this Observatory on 108 days which were counted as 81¼ effective days. The mean daily areas of hydrogen prominences in square minutes of arc are given below :—

	Mean daily areas (square minutes).
North	0·71
South	0·41
Total	1·12

Compared with the previous half-year, H*a* prominence areas show only a small increase, *viz.*, 3 per cent. The ratio of H*a* areas to calcium areas is 46 per cent., which is less than in the first half-year. The latitude distribution of H*a* prominences is similar to that of calcium prominences.

Metallic Prominences.—No metallic prominences were observed during the half-year, as against 3 in the first half.

Displacement of the Hydrogen Line.—Particulars of the displacements observed in the chromosphere and prominences are given below :—

TABLE II.—DISPLACEMENTS OF THE HYDROGEN LINE.

Date.		Hour I. S. T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
1933.		H.	M.	°	°		A.	A.	A.	
July	3	9	58	66		E		0·5		At top.
	18	8	47	32		W		0·5		At base, extends over 2° from + 31° to + 33°.
August	25	8	18	46·5		W	0·5			At base.
	28	9	28		28	W	0·5			Do.
September	16	9	15		34·5	E		0·5		At base.
	23	9	01	58·5		W		0·5		In chromosphere.
October	22	10	02	37		E		2		At base. Extends over 2° from + 36° to + 38°.
	23	8	32	21		E		0·5		In chromosphere.
	26	9	14	31		W	Slight			Do.
November	2	10	20	85·5		E	1			At top.
	13	9	06	42		E	1			Do.
	16	9	17		63	W		Slight		At base.
	23	10	17	34		E		0·5		In chromosphere.
December	4	9	52	87		E	1·5			At top.
	6	9	01	56		E	0·5			Do.
	9	9	40	10		E		0·5		In chromosphere.
	11	10	01		57	W		0·5		At top.
	17	8	35	42		W		0·5		In chromosphere.
	19	9	09		27	E		0·5		At base.
	21	9	27		54	W		Slight		In chromosphere.
	29	9	14	45		E		Slight		Do.
	30	9	25	51		W		1·5		At top.

The total number of displacements was 22 as against 64 in the previous half year and their distribution was as follows —

		North	South
1°—30°		2	2
31°—60°		11	3
61°—90°		3	1
	Total	16	6

East limb		12
West limb		10
	Total	22

Of these displacements 7 were towards the red, and 15 towards the violet

Reversals and Displacements on the Sun's Disc—One bright reversal of the Hα line and one dark reversal of the D_3 line were observed during the half year No displacements of the Hα line were observed The distribution is given below —

	North	South	East	West
Bright reversals of Hα	1		1	
Dark reversals of D_3	1		1	
Displacements of Hα				

Prominences projected on the Disc as Absorption Markings—Photographs of the sun's disc in Hα light were available from Kodaikanal and the co operating observatories for a total of 184 days which were counted as 162½ effective days The mean daily areas of Hα absorption markings (corrected for foreshortening) in millionths of the sun's visible hemisphere and their mean daily numbers are given below —

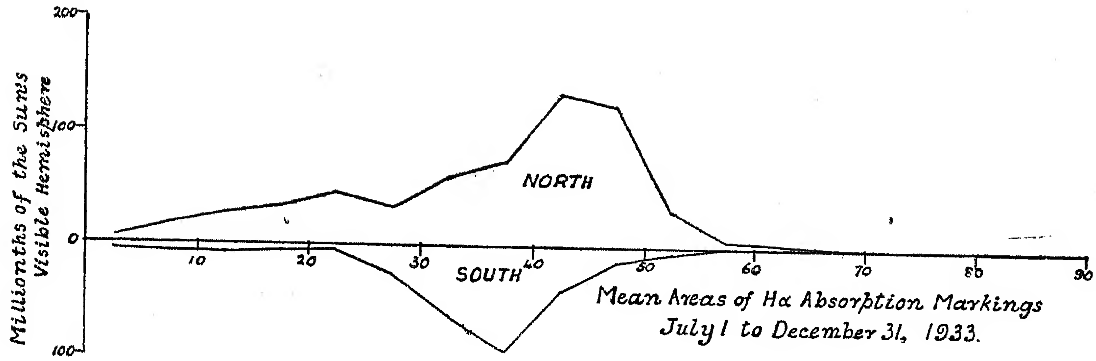
		Mean daily areas	Mean daily numbers
North		588	4 07
South		286	2 07
	Total	874	6 14

The above show a decrease of 32 per cent in areas and 28 per cent in numbers compared with the previous half year, the decrease being greater in the northern hemisphere than in the southern

For comparison with bulletins issued prior to the co operation of other observatories, the means based on Kodaikanal photographs alone are also given, 124 days of observation being reckoned as 99¾ effective days

		Mean daily areas	Mean daily numbers
North (Kodaikanal photographs only)		581	3 82
South Do		310	2 00
	Total	891	5 82

The distribution of mean daily areas in latitude is shown in the following diagram Compared with the first half of the year there is decreased activity in the northern hemisphere from 0° to 40°, and decreased activity in the southern near the equator and in the belt 40°—45°



As in the previous half-year, both areas and numbers show an eastern preponderance, the percentage in areas being 54 and in numbers 52.

The mean daily areas of Hα absorption markings uncorrected for foreshortening are given below :—

	Mean daily areas.
North	341
South	175
Total	516

The uncorrected areas amount to 59 per cent. of the corrected ones, which is a slight increase over the two previous half-years.

The curve of distribution in latitude is similar to that for the corrected areas as usual.

Thanks are due to the co-operating observatories for the photographs supplied by them.

KODAIKÀNAL,
28th January 1935.

T. RÒYDS,
Director, Kodaikanal Observatory.

GIPD—472 Kodaikanal Ob.—20-6-35—340.

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Kodaikanal Observatory.

BULLETIN No. CV.

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE FIRST HALF OF THE YEAR 1934.

In pursuance of the programme of work adopted since 1st January 1923 under the auspices of the International Astronomical Union, all observatories taking spectroheliograms of the sun have been asked to co-operate with the Kodaikanal Observatory by supplying copies of their photographs for those days when the Kodaikanal records are imperfect or wanting. In response to our requirements for the first half of the year 1934, the Mount Wilson Observatory supplied calcium (K_{232}) prominence plates for 25 days and H α disc plates for 10 days, the Meudon Observatory supplied calcium (K_3) disc plates for 5 days and H α disc plates for 18 days, and the Pitch Hill Observatory, Ewhurst (Mr. J. Evershed's), supplied H α disc plates for 7 days.

When only incomplete or im perfect photographs for any day are available from more than one observatory the best photograph is chosen as representing the solar activity of that day, after weighting it according to its quality, and the remaining photographs are ignored.

Calcium Prominences at the Limb.—The mean daily areas and numbers of prominences photographed during the half-year by means of the K line of calcium are given below. The means are corrected for incomplete or imperfect observations, the total of 181 days for which plates were available being reduced to 167 effective days.

	Mean daily areas. (Square minutes.)	Mean daily numbers.
North	1·72	6·17
South	1·68	6·39
Total	3·40	12·56

Compared with the previous half-year, areas and numbers show an increase of 50 per cent. and 53 per cent., respectively.

For comparison with bulletins issued prior to the co-operation of other observatories, the means based on Kodaikanal photographs alone are also given, 158 days of observation being counted as 146 effective days.

	Mean daily areas. (Square minutes.)	Mean daily numbers.
North (Kodaikanal photographs only)	1·80	6·38
South (Ditto)	1·75	6·55
Total	3·55	12·93

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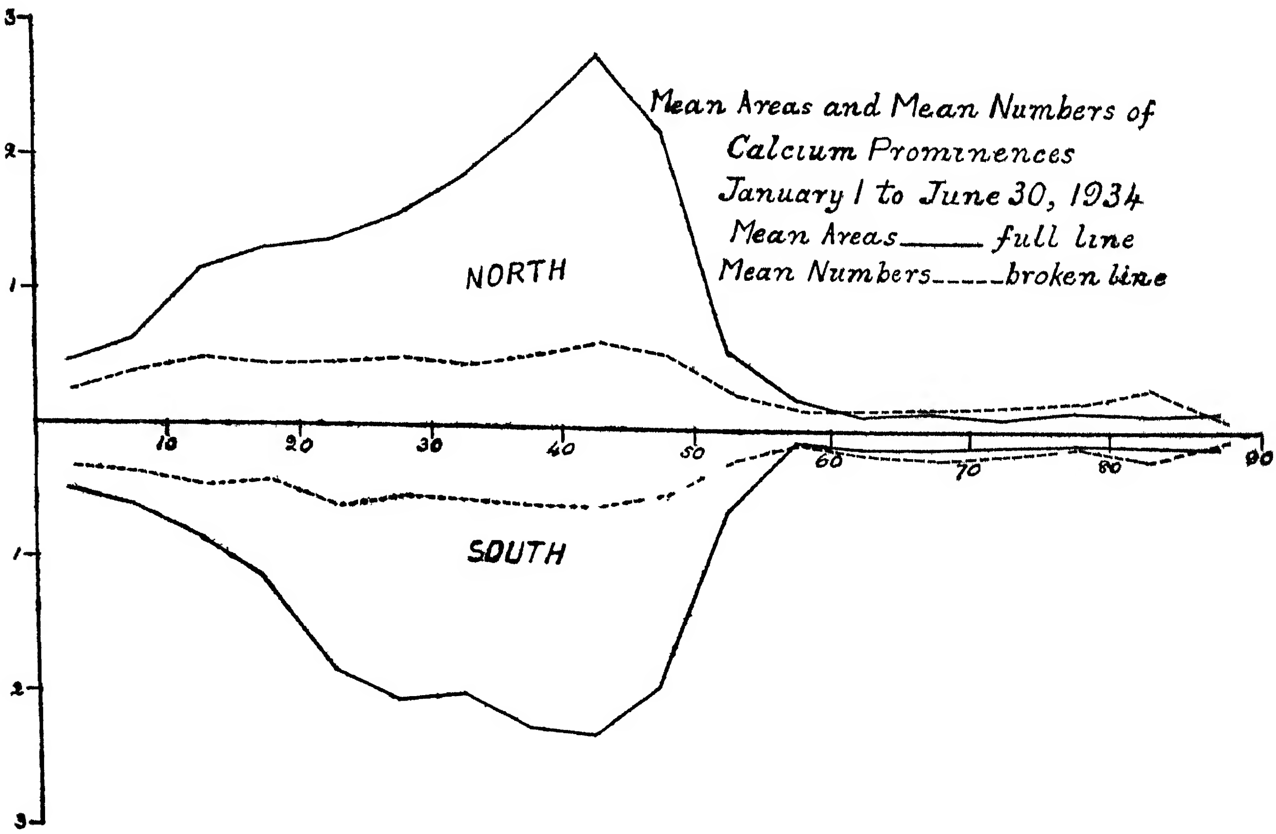
The distribution of prominences in latitude is represented in the following diagram, in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude. The ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line.

Compared with the previous half year, there has been increased activity in nearly all belts of latitude, particularly in the belts 10°—20,° 45°—55° in the northern hemisphere and in the belts 10°—30°, 40°—45° in the southern hemisphere. The lower of these belts corresponds to the sunspot belts. The activity in the southern hemisphere has increased sufficiently to be almost equal to that in the northern. The maximum of prominence activity has moved about 5° towards the poles in both hemispheres since the previous half year.



The monthly, quarterly and half yearly areas and numbers and the mean height and the mean extent of the prominences on photographs from all co operating observatories are given in table I. The unit of area is 1 square minute of arc. The mean height is derived by adding together the greatest heights reached by individual prominences and dividing by the total number of prominences observed, the mean extent is derived by adding together the lengths of the base on the chromosphere of individual prominences and dividing by the total number of prominences.

TABLE I.—ABSTRACT FOR THE FIRST HALF OF 1934.

Months. 1934.	Number of days (effective).	Areas.	Numbers.	Daily Areas.	means. Numbers.	Mean Height.	Mean Extent.
January	27	64·9	271	2·4	10·0	35·4	3·89
February	28	87·1	365	3·1	13·0	30·3	4·32
March	29¾	79·7	355	2·7	11·9	34·0	4·64
April	28¼	98·7	382	3·5	13·5	33·0	4·86
May	29¼	148·1	395	5·1	13·5	35·8	6·34
June	24¾	89·5	329	3·6	13·3	33·8	3·78
First quarter	84¾	231·7	991	2·7	11·7	33·0	4·32
Second quarter	82¼	336·3	1106	4·1	13·4	34·2	5·07
First half	167	567·0	2097	3·4	12·6	33·7	4·71

Distribution East and West of the Sun's Axis.

Unlike the previous half-year both areas and numbers show a slight preponderance in the east limb as will be seen from the following table :—

1934 January to June.	East.	West.	Percentage East.
Total number observed	1,073	1,024	51·17
Total areas in square minutes	3,008	2,673	52·95

Hydrogen Prominences at the Limb :—The taking of daily photographs of hydrogen prominences as part of the regular programme has been discontinued from the beginning of the year.

Metallic Prominences :—Five metallic prominences were observed during the half-year and their details are given below :—

TABLE II.—LIST OF METALLIC PROMINENCES. JANUARY TO JUNE 1934.

Date.	Time I. S. T.		Base.	Latitude.		Limb.	Height.	Lines (See note at end of table.)
				North.	South.			
1934.	H.	M.	°	°	°		″	
January	..			Nil.				
February 24	10	15	2	28	..	E	15	4, 10.
March				Nil.				
April 28	9	37	6	..	26	W	30	1, 2, 4, 8, 9, 10, 11.
May 16	8	41	4	24	..	E	20	1, 3, 4, 5, 7, 8, 10, 11, 12.
26	9	44	2	..	34	W	10	1, 3, 4, 8, 9, 10, 11, 12.
27	9	25	4	..	32	W	10	1, 3, 4, 9 10, 11, 12.
June				Nil.				

Note.—The key to the wave-lengths of metallic lines is as follows :—

No.	λ	Element.	No.	λ	Element.
1	4924·1	Fe +	7	5276·2	Fe + Cr.
2	5016·0	He	8	5316·8	Fe +
3	5018·6	Fe +	9	5363·0	Fe +
4	b_4, b_3, b_2, b_1.	Mg. Fe +	10	D_2, D_1.	Na
5	5234·8	Fe +	11	6677	He
6	5276·0	Cr.	12	7065	He

The distribution of metallic prominences was as follows —

	1°—10°	11°—20°	21°—30°	31°—430°	Mean latitude	Extreme latitudes
North	0	0	2	0	26°	24° & 28°
South	0	0	1	2	30° 7	26° & 34°

Two were on the east limb and three on the west limb

Displacements of the Hydrogen Line —Particulars of the displacements observed in the chromosphere and prominences are given in the following table —

TABLE III —DISPLACEMENTS OF HYDROGEN LINE

Date 1934		Hour I S T H	M	Latitude North	Latitude South	Limb	Displacement Red A	Displacement Violet A	Displacement Both ways A	Remarks
January	2	10	22	35		E	0 5			At base
	3	9	26		17	E	1			Do
	4	9	52	27		E		1		At top
	5	9	08		39 5	W		0 5		At base
		9	04	12		W		0 5		Throughout the prominence
	12	9	30	57		E	0 5			At top
	17	10	25	3 5		W	0 5			Do
February	1	9	03	66		E		1 5		At base
	2	9	12	26		W		1		Do
		9	9	51 5		W		1		Do
	9	8	50	45		E		1		Do
		8	40	35 5		E	0 5			In Chromosphere
	10	9	35	5 5		E	0 5			At base
		9	27	27		W	1 5			At top
	11	8	47	42 5		E		0 5		At base
	13	8	26	33 5		E		0 5		At top
	14	8	26	42 5		E		0 5		In the middle of the prominence.
		8	40		31 5	W		0 5		At top
	16	9	22	22 5		E	0 5			Do
		9	18		34 5	W	Sl			Do
	19	10	34	58 5		E	1			In Chromosphere
	20	9	38	24		E		1		At base
	21	8	58	25		E		0 5		At top
		9	05	41 5		W		0 5		At base
		9	04	44 5		W	1			At top
	22	9	14	78 5		E		1 5		Do
		9	16	82 0		W		1		In Chromosphere
	23	9	35	34 5		E	0 5			At top
	26	10	22	64				0 5		In Chromosphere
	28	9	5	38 5		E		0 5		At top
March	2	9	11	59 5		W	Sl			In Chromosphere
	20	8	36	10		F		0 5		At top
	22	9	03	33 5		E		0 5		At top, extends over 2° from 34° to 36°
	24	9	00	21		E		Sl		At top
	26	9	12	29		E	Sl			At base
	28	9	20	27 5		E		1		At top
	29	9	12	10 5		W	1 5			Do
	30	9	04		1	E	Sl			Do

TABLE III.—DISPLACEMENTS OF HYDROGEN LINE—*contd.*

Date. 1934.		Hour I. S. T. H.	M.	Latitude. North. °	South. °	Limb.	Displacement. Red. A.	Violet. A.	Both ways. A.	Remarks.
April	1	9	04	36·5		E	1			At top.
		9	18		73	E		1		In Chromosphere.
	4	9	47		25·5	E		1		At top.
	5	9	49	12		E		0·5		Do.
	11	8	48		44	E	Sl			At base.
		8	40	55·5		W		Sl		At top.
	13	8	55	41·5		E		Sl		At base.
	17	8	50	40		W		0·5		At top.
		8	48	42		W	0·5			At base.
	20	8	34	45		E		Sl		At top.
		8	55		40·5	E	Sl			Do.
	22	8	48	10		W	Sl			Do.
	24	9	06	56·5		W		Sl		Do.
	25	8	51		31	W		0·5		Do Extends over 2° from 30° to 32°.
		8	50		25	W		0·5		At top.
	27	9	5		73·5	E	1			Do.
	28	9	20	71·5		E			Sl	In Chromosphere.
		9	48		26	W	6			At top extends over 6° from 23° to 29°.
		9	55		28	W	2·5	3		Both at top, extends over 2° from 27° to 29°.
		9	44		24	W	3·5			At top, extends over 2° from 23° to 25°.
May	1	8	42	43·5		E		Sl		At top.
	2	8	54	35		E	Sl			At base.
	3	8	58	38		W		Sl		In the middle of the prominence, extends over 2° from 37° to 39°.
	4	8	50	1		W		Sl		At top.
	5	10	32		3	E	0·5			Do.
	6	9	30	37		E		Sl		In Chromosphere.
		9	20	74·5		W			1	At top.
	9	9	48	71·5		E	Sl			In Chromosphere.
		9	7		25	E	0·5			At top, extends over 2° from 24° to 26°.
	16	8	41	24		E		2		At top, extends over 4° from 22° to 26°.
		9	55	5		W		0·5		At top, extends over 2° from 4° to 6°.
	20	9	26		69·5	E	2			At top.
		9	9	73·5		W	1	1·5		To red at top and to violet at base.
		9	6	86·5		W	Sl			In Chromosphere.
	21	9	20	35·5		E		0·5		At top.
		8	56	82		W	1			In Chromosphere.
	23	8	04	44·5		W		Sl		At top.
	26	10	00		87·5	W	1			At base.
		9	44		34	W	1	0·5		Extends over 2° from —33° to —35°.
		9	10		16	W	1			At top, extends over 2° from —15° to —17°.
		9	6	19		W	0·5			At top.
	27	9	22		33·5	W	1·5			At top.
		9	21		29	W	1·5			At top, extends over 2° from —28° to —30°.
		9	18		16·5	W	0·5			At top, extends over 3° from —15° to —18°.
	30	10	5	28·5		W		0·5		At top.
June	3	8	44	44·5		E	Sl			At base.
	4	9	48		80	E		0·5		Do.
		9	37		13·5	W	1			At top.
		9	37		10·5	W		1		Do.
	15	9	6	53		W		Sl		Do.
	22	8	48		60	W		0·5		Do.

The total number of displacements was 92 as against 22 in the previous half year and their distribution was as follows —

	North	South
1° to 30°	21	15
31° to 60°	30	10
61° to 90°	11	5
	62	30

East Limb	46
West Limb	46
Total	92

Of these displacements, 42 were towards the red, 48 towards the violet and 2 both ways simultaneously

Reversals and Displacements on the Sun's Disc —Sixty three bright reversals of the H α line, 61 dark reversals of the D_3 line and 11 displacements of the H α line were observed during the half year Their distribution is given below —

	North	South	East	West
Bright reversals of H α	35	28	28	35
Dark reversals of D_3	34	27	28	33
Displacements of H α	3	8	3	8

Five displacements were towards the red, four towards the violet and two both ways simultaneously

Prominences projected on the Disc as Absorption Markings —Photographs of the sun's disc in H α light were available from Kodaikanal and the co operating observatories for a total of 180 days which were counted as 175 effective days The mean daily areas of H α absorption markings (corrected for fore shortening) in millionths of the sun's visible hemisphere and their mean daily numbers are given below —

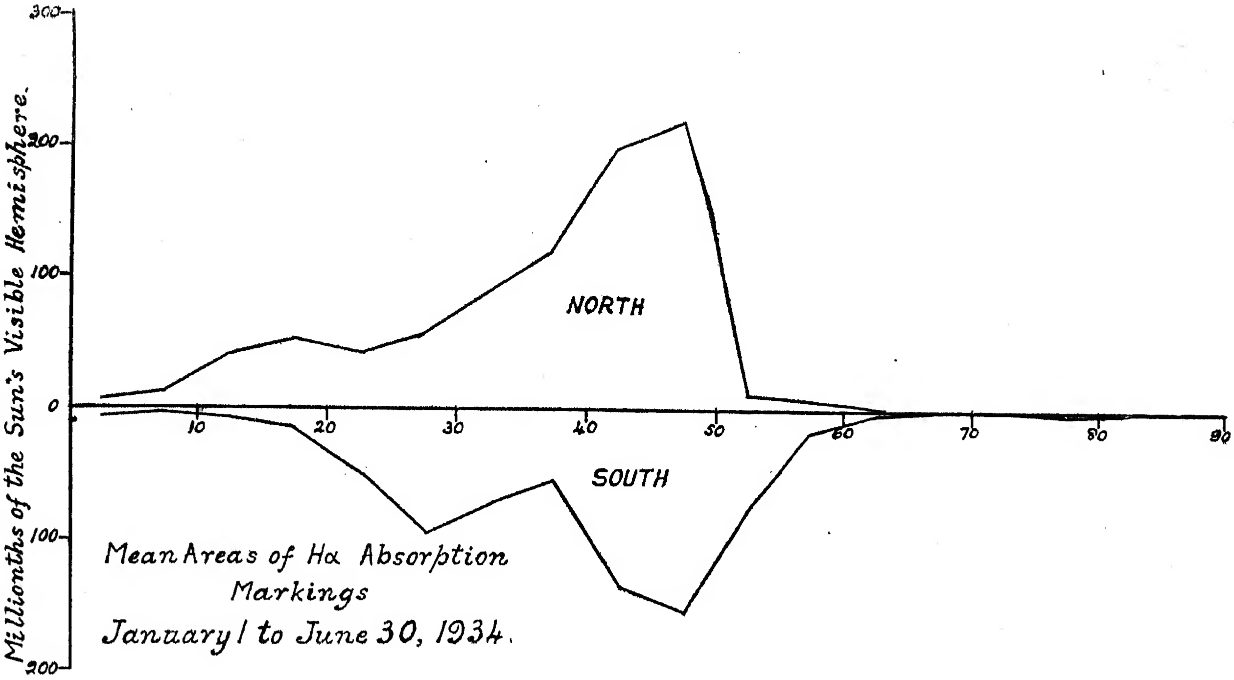
	Mean daily areas	Mean daily numbers
North	859	4 74
South	703	3 12
Total	1,562	8 86

The above show an increase of 79 per cent in areas and 44 per cent in numbers, compared with the previous half year, the increase being very marked in the southern hemisphere

For comparison with bulletins issued prior to the co operation of other observatories, the means based on Kodaikanal photographs alone are also given 153 days of observation being reduced to 146 effective days.

	Mean daily areas	Mean daily numbers
North (Kodaikanal photographs only)	847	4 82
South (Ditto)	684	4 24
Total	1,531	9 06

The distribution of mean daily areas in latitude is shown in the following diagram. As in the case of prominence areas, there has been a general increase in nearly all latitudes, except near the poles. The greatest increase is in the same belts as for prominence areas and the effect of the sunspot belts is again shown in the case of H α dark markings. The same advance of 5° towards the poles is also seen in the maximum activity.



As in the previous half-year, both areas and numbers show an eastern preponderance, the percentage in areas being 55 and in numbers 52.

The mean daily areas of H α absorption markings uncorrected for fore-shortening are given below :—

	Mean daily areas.
North	444
South	366
Total .	810

The uncorrected areas amount to 52 per cent. of the corrected ones, the percentage being slightly less than normal.

The curve of distribution in latitude is similar to that for the corrected areas as usual.

Thanks are due to the co-operating observatories for the photographs supplied by them.

KODAIKANAL,

30th March 1935.

T. ROYDS,

Director, Kodaikanal Observatory.

GIPD—M10 Dr. of Kodai Kanal—30-5-35—340.

No. K. B./106.

Kodaikanal Observatory.

BULLETIN No. CVI.

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE SECOND HALF OF THE YEAR 1934.

In pursuance of the programme of work adopted since 1st January 1923 under the auspices of the International Astronomical Union, all observatories taking spectroheliograms of the sun have been asked to co-operate with the Kodaikanal Observatory by supplying copies of their photographs for those days when the Kodaikanal records are imperfect or wanting. In response to our requirements for the second half of the year 1934, the Mount Wilson Observatory supplied calcium (K_{232}) prominence plates for 36 days and Hα disc plates for 20 days, the Meudon Observatory supplied calcium (K_3) disc plates for 9 days and Hα disc plates for 30 days, and the Pitch Hill Observatory, Ewhurst (Mr. J. Evershed's) supplied hydrogen prominence plate for 1 day and Hα disc plates for 7 days.

When only incomplete or imperfect photographs for any day are available from more than one observatory the best photograph is chosen as representing the solar activity of that day, after weighting it according to its quality, and the remaining photographs are ignored.

Calcium Prominences at the Limb.—The mean daily areas and numbers of prominences photographed during the half-year by means of the K line of calcium are given below. The means are corrected for incomplete or imperfect observations, the total of 176 days for which plates were available being reduced to 148 effective days.

	Mean daily areas (Square minutes).	Mean daily numbers.
North	1·97	6·70
South	1·96	6·65
Total . .	3·93	13·35

Compared with the previous half-year, areas and numbers show an increase of 16 per cent. and 6 per cent. respectively.

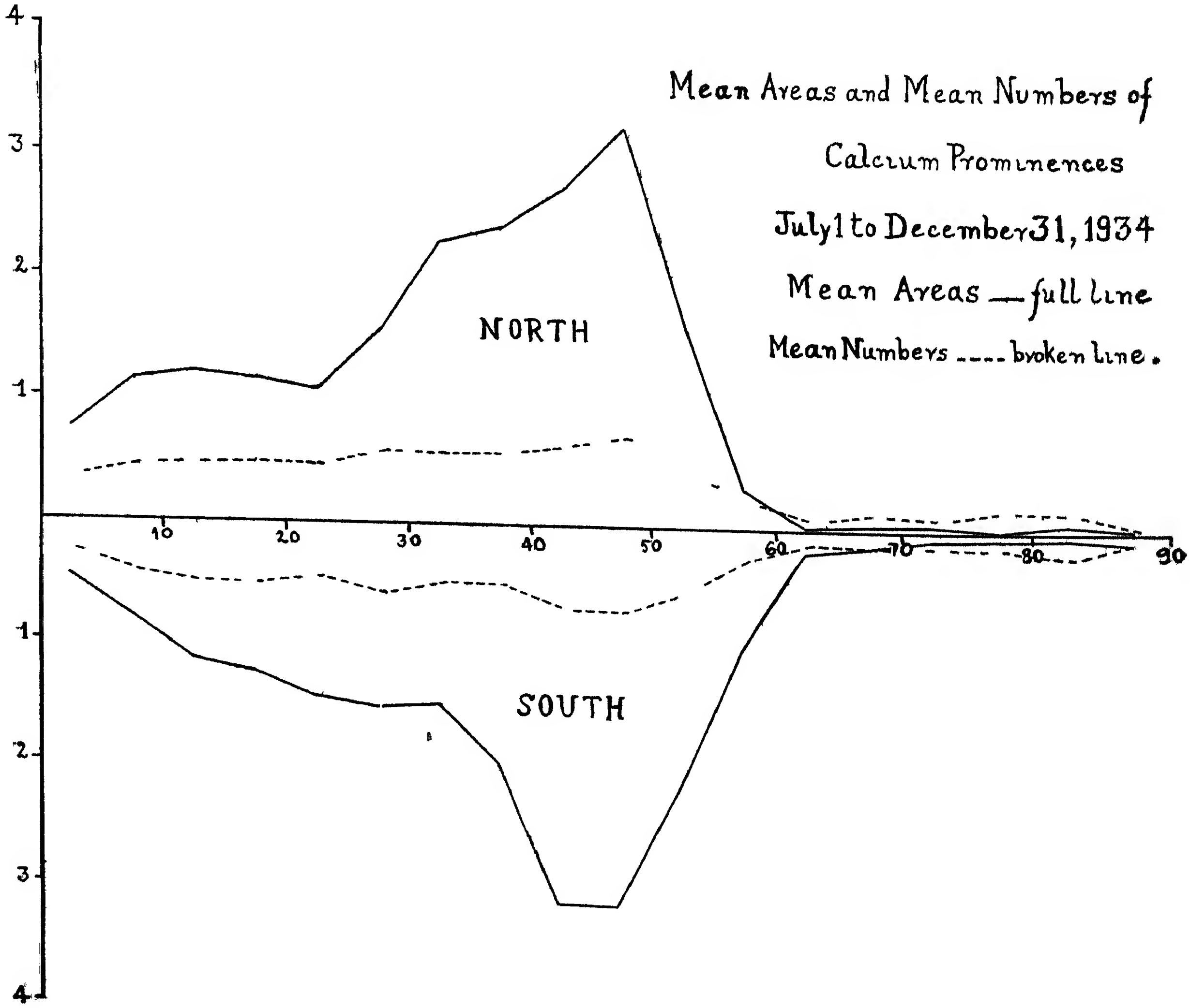
For comparison with bulletins issued prior to the co-operation of other observatories the means based on Kodaikanal photographs alone are also given, 145 days of observation being counted as 127 effective days.

	Mean daily areas (Square minutes).	Mean daily numbers.
North (Kodaikanal Photographs only) . . .	1·99	6·86
South (Do) . . .	2·05	6·78
Total . . .	4·04	13·64

Price annas 7 or 9d.

The distribution of prominences in latitude is represented in the following diagram, in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude. The ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line.

The general increase in prominence activity observed in the first half year is maintained. Compared with the first half of 1934, there has been increased activity in the belts 45° to 50° in the northern hemisphere and in the belt 40° to 50° in the southern hemisphere. The maximum of prominence activity has again moved about 5° towards the poles in both the hemispheres.



The monthly, quarterly and half yearly areas and numbers and the mean height and the mean extent of the prominences on photographs from all co-operating observatories are given in Table I. The unit of area is 1 square minute of arc. The mean height is derived by adding together the greatest heights reached by individual prominences and dividing by the total number of prominences observed, the mean extent is derived by adding together the lengths of the base on the chromosphere of individual prominences and dividing by the total number of prominences.

TABLE I.—ABSTRACT FOR THE SECOND HALF OF 1934.

Months. 1934.	Number of days (effective).	Areas.	Numbers.	Daily means. Areas.	Daily means. Numbers.	Mean height. ″	Mean extent. °
July	24½	120·3	308	4·9	12·6	38·8	4·89
August	24½	99·7	357	4·1	14·6	34·5	4·04
September	28½	116·2	424	4·1	15·0	33·0	4·26
October	23	82·9	291	3·6	12·7	35·3	3·69
November	23½	89·7	275	3·8	11·7	38·0	4·83
December	24¼	73·1	320	3·0	13·2	32·5	3·50
Third quarter	77½	336·2	1089	4·4	14·1	35·1	4·27
Fourth quarter	70¾	245·7	886	3·5	12·5	35·1	3·97
Second half year	148	581·9	1975	3·9	13·3	35·1	4·14

Distribution East and West of the Sun's Axis.—As in the previous half-year, both areas and numbers show a slight preponderance in the east limb as will be seen from the following table :—

1934 July to December.	East.	West.	Percentage East.
Total number observed	1013	962	51·29
Total areas in square minutes	305·3	276·7	52·45

Metallic Prominences.—Three metallic prominences were observed during the half-year and their details are given below :—

TABLE II.—LIST OF METALLIC PROMINENCES. JULY TO DECEMBER 1934.

Date. 1934.	Time I. S. T. H.	M.	Base. °	Latitude. North. °	Latitude. South. °	Limb.	Height. ″	Lines (See note at end of table).
July				Nil.				
August 6	9	26	2		35	E	15	4, 10
September				Nil.				
October				Nil.				
November 19	10	40	8		22	E	35	4, 10
December 18	10	32	1		21·5	W		4, 10

Note.—The key to the wave-lengths of metallic lines is as follows :—

No.	λ	Element.	No.	λ	Element.
1	4924·1	Fe+	7	5276·2	Fe+
2	5016·0	He	8	5316·8	Fe+
3	5018·6	Fe	9	5363·0	Fe+
4	b_4, b_3, b_2, b_1	Mg. Fe+	10	D_2, D_1	Na
5	5234·8	Fe+	11	6677	He
6	5276·0	Cr	12	7065	He

The distribution of metallic prominences was as follows —

	1°—10°	11°—20°	21°—30°	31°—40°	Mean latitude	Extreme latitudes
					°	°
North						
South			2	1	26° 2	21° 5 & 35°

Two were on the east limb and one on the west limb

Displacements of the Hydrogen line —Particulars of the displacements observed in the chromosphere and prominences are given in the following table —

Table III —Displacements of Hydrogen Line

Date 1934		Hour I S T		Latitude North	Latitude South	Limb	Displacement Red	Displacement Violet	Displacement Both ways	Remarks
		H	M	°	°		A	A	A	
July	13	10	48	37		E		Sl		At base
	14	8	45	73 5		W		Sl		In chromosphere
	15	9	45	4		E		1		At base
	17	8	59	31		W	Sl			Do
	22	10	16	25 5		E	0 5			At top
August	6	9	8	83 5		E		0 5		At top
		9	22	17 5		E	1			Do extends over 5° from + 15° to + 20°
		9	26		35	E		1		At top
		9	26		40	E		1		Do Extends over 2° from — 39° to — 41°
		9	26		48	E	2			Do Extends over 4° from — 46° to — 50°
	7	8	46	78 5		W	Sl			In chromosphere
	23	8	54	35 5		W	1			At base Extends over 2° from + 34 5° to + 36 5°
	26	8	44	79 5		W	Sl			In chromosphere
		8	45	85		W		Sl		Do
	28	9	40		4	E		Sl		Do
September	3	9	15		14	W	1			At top
		9	14	25		W	0 5			At base
	4	10	8	82 5		E	Sl			In chromosphere
	7	9	20		27	W	Sl			Do
		9	18	1		W		Sl		Do
	13	9	21		38	E	Sl			At base
	15	9	40		30 5	W	1			At top
		9	38		26	W	1			Do
	18	9	6	76		E		Sl		Do
		9	20	55 5		E		Sl		At base
October	5	9	50		49 5	E		1		At top
	8	8	20	60 5		W		Sl		Do Extends over 2° from + 59 5° to + 61 5°
November	3	10	27		29	E	1			At top
	5	9	42	28		E		Sl		At base
	19	10	40		18 5	E		1		Do
	22	8	54		42	W	Sl			At top

TABLE III.—DISPLACEMENTS OF HYDROGEN LINE

Date. 1934.		Hour. I. S. T. H.	M.	Latitude. North. °	South. °	Limb.	Displacement. Red. A	Violet. A	Both ways. A	Remarks.
December	1	11	20		73	E		Sl		At top.
	7	8	57		61	W	0·5			In chromosphere.
	8	10	30	84		W	1			At top.
		10	32	86		W		1		Do.
	9	9	55	54.5		E	0·5			At base.
	18	10	54		25	E		Sl		At top.
		10	18	46		W	0·5			Do.
		10	15	61		W		Sl		At base.
	19	10	7	45		E	Sl			At top.
		10	15		28·5	E	0·5			Do.
	24	9	45		26·5	E			Sl	
	25	8	55		35	E	Sl			At base. Extends over 2° from — 34° to — 36°.
	27	10	33		49	E		Sl		In chromosphere.
	31	9	37	31·5		W	3			At top. Extends over 3° from + 30° to + 33°.

The total number of displacements was 45 as against 92 in the previous half-year and their distribution was as follows :—

	North.	South.
1 to 30°	6	9
31° to 60°	8	9
61° to 90°	11	2
Total	25	20

East Limb	25
West Limb	20
Total	45

Of these displacements, 24 were towards the red, 20 towards the violet and one both ways simultaneously.

Reversals and Displacements on the Sun's Disc.—Fifty-five bright reversals of the Hα line, 45 dark reversals of the D_3 line and 3 displacements of the Hα line were observed during the half-year. Their distribution is given below :—

	North.	South.	East.	West.
Bright reversals of Hα	28	27	38	17
Dark reversals of D_3	24	21	32	13
Displacements of Hα	1	2	3	..

Two displacements were towards the red, none towards the violet and one both ways simultaneously.

Prominences projected on the Disc as Absorption Markings.—Photographs of the sun's disc in Hα light were available from Kodaikanal and the co-operating observatories for a total of 177 days which were counted as

161 effective days The mean daily areas of Hα absorption markings (corrected for foreshortening) in millionths of the sun's visible hemisphere and their mean daily numbers are given below

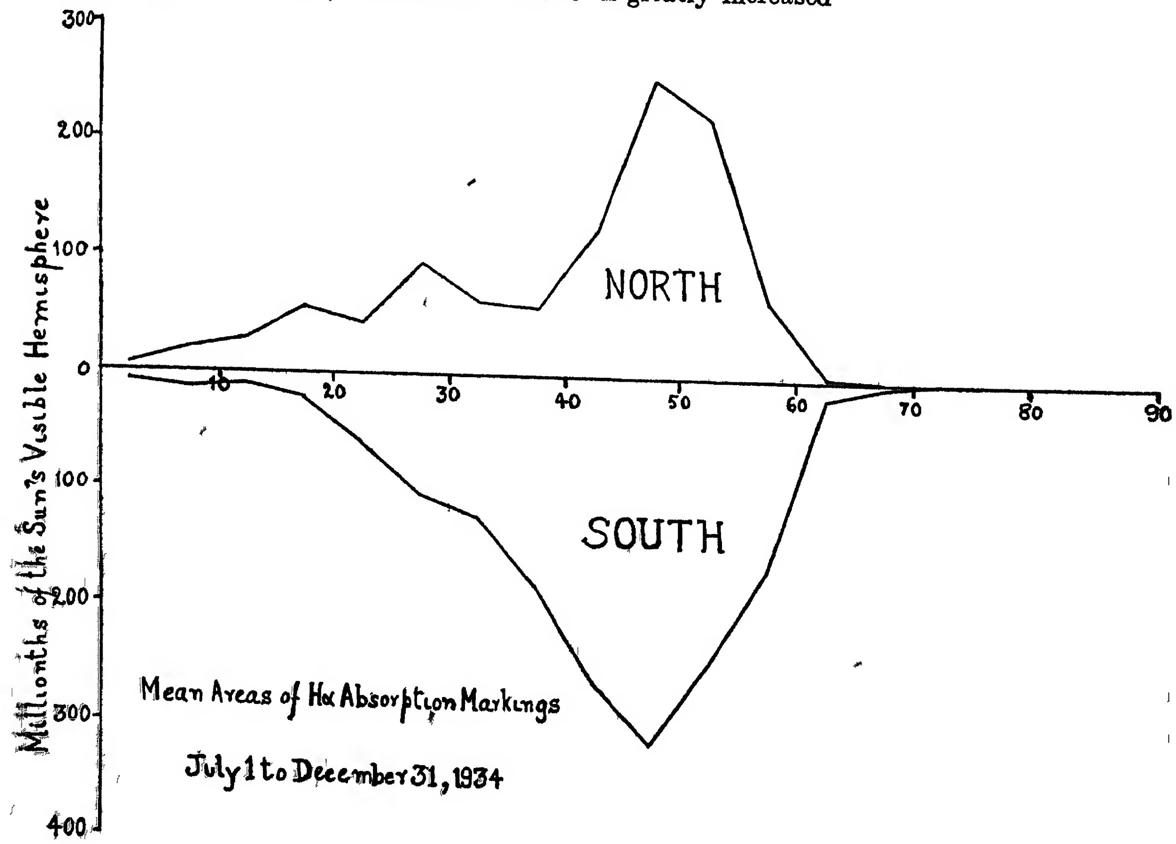
	Mean daily areas	Mean daily numbers
North	1050	5 15
South	1511	6 76
Total	2561	11 91

The above figures show an increase of 64 per cent in areas and 34 per cent in numbers, compared with the first half of the year, the activity in the southern hemisphere being more than doubled

For comparison with bulletins issued prior to the co operation of other observatories the means based on Kodaikanal photographs alone are also given, 135 days of observation being reduced to 122 effective days

	Mean daily areas	Mean daily numbers
North (Kodaikanal photographs only)	1102	5 04
South (Do)	1439	6 61
Total	2541	11 65

The distribution of mean daily areas in latitude is shown in the following diagram Compared with the previous half year there has been general increase in activity in both the hemispheres, the increase in the southern hemisphere being very marked The maximum of activity is maintained in the zone 45° to 50° in both hemispheres as in the previous half-year and no march of the maximum towards the poles is observed, although the activity between 50° and 60° is greatly increased



Compared with the previous half-year, areas show a slight eastern preponderance and numbers a slight defect, the percentage in areas being 52 and in numbers 49·5.

The mean daily areas of Hα absorption markings uncorrected for foreshortening are given below.

	Mean daily areas.
North	550
South	714
Total . .	1264

The uncorrected areas amount to 49 per cent. of the corrected ones, the percentage being slightly less than the previous half-year.

The curve of distribution in latitude is similar to that for the corrected areas as usual.

Thanks are due to the co-operating observatories for the photographs supplied by them.

KODAIKANAL,
9th August 1935.

T. ROYDS,
Director, Kodaikanal Observatory.

GIPD—M128 Dr Kodai Kanal—29-12-35—340.

NO—KB/107.

Kodaikanal Observatory.

BULLETIN No. CVII.

OXYGEN IN THE SUN'S CHROMOSPHERE*

BY T. ROYDS, D.Sc.

Abstract.—Photographs taken at the Kodaikanal Observatory show that oxygen is a normal constituent of the sun's chromosphere, and is probably in great abundance. The plate attached is a reproduction from one of the photographs obtained when the slit of the spectrograph was placed tangentially to the image of the sun's limb, and shows the infra-red triplet of oxygen at $\lambda\lambda$ 7771, 7774 and 7775 as emission lines in the sun's chromosphere. The greatest height reached by oxygen is apparently 3·5″ but this may be an underestimate. The significance of the presence of oxygen in the chromosphere for the theory of support of the chromosphere is discussed.

Oxygen was discovered in the sun by Runge and Paschen [1] who observed the infra-red triplet $\lambda\lambda$ 7771, 7774 and 7775 as absorption lines in the Fraunhofer spectrum, and it was conclusively proved by the Royal Observatory, Edinburgh [2] that these lines originated in the sun. It is also known[3] that the oxygen doublet λ 8446 is present in the Fraunhofer spectrum. These five lines are all the known lines in the sun's spectrum due to oxygen.

The author has now succeeded in photographing the oxygen triplet as emission lines in the chromosphere. The image of the sun's limb was thrown on the slit plate of the large spectrograph of this observatory with the slit tangential to the sun's limb which was as near as possible to the slit without admitting photospheric light into the spectrograph. The spectrum was photographed in the first order of a plane Rowland grating on Ilford infra-red sensitive plates.

The plate accompanying this bulletin illustrates the oxygen triplet in one of the photographs obtained of the chromospheric spectrum. Fig. B shows the oxygen triplet as bright lines, as compared with the ordinary solar spectrum in fig. A, where the oxygen lines are seen as absorption lines as is well known. The background of fig. B is due to the sky spectrum which consists of scattered light from the sun, and hence shows the usual continuous spectrum and absorption lines of the solar spectrum except where emission lines due to the sun's chromosphere are sufficiently strong to show brighter than the scattered sky spectrum. When the spectrograph slit is not close to the sun's limb, the oxygen triplet is seen in the sky spectrum as absorption lines, but when the sun's chromosphere impinges on the slit, the lines are reversed into bright lines as may be seen in fig B. In case these reversals may be difficult to see in the reproduction, microphotometric records of the photographs

*Since this bulletin was sent to press the author became aware of Curtis & Burns' paper in Publications of the Allegheny Observatory, VI, 95, 1925, on the infra-red flash and coronal spectra, eclipse of January 24th, 1925. Regarding the oxygen lines they say, "The oxygen triplet 7772, 7774 and 7775A appears as one broad line on our plates. It is very strong at low levels and weaker at higher levels, though faintly present in a high prominence." The discovery of the presence of oxygen in the chromosphere must therefore be credited to Curtis and Burns. So far as I am aware, the oxygen triplet in the flash spectrum has not been photographed in any subsequent eclipse, notwithstanding the great improvement in red sensitive plates.

[1] Runge and Paschen, A. J. 4. 317. 1896.

[2] Royal Observatory, Edinburgh, M. N. R. A. S. 73. 31. 1912.

[3] Mt. Wilson Revision of Rowland's Table, 1928.

Price As. 4 or 5d.

have been added Fig b is the microphotometric record across the right hand half of fig B, and fig a is the record across the same part of fig A In fig a, the oxygen lines due to the solar spectrum show as absorption lines (absorption is shown downwards from the continuous spectrum) exactly similar to the neighbouring iron and nickel lines, whereas in fig b the oxygen lines due to the chromosphere are shown as emission lines (*i e*, upwards from the continuous spectrum) in the direction opposite to the neighbouring iron and nickel absorption lines in the sky spectrum of figs b and B, and in the solar spectrum of figs a and A This shows that oxygen is present in the chromosphere but not iron and nickel The scale of the microphotometer records is arbitrary and has no photometric significance It should be mentioned that the graininess of the photographs has been subdued in obtaining the photometric records for the sake of clearness, but at a slight sacrifice of resolving power

The presence of the bright oxygen lines in the chromospheric spectrum seems to be a permanent feature of the chromosphere Evidence of the bright reversals was secured in the first photographs attempted and they have been photographed every day since the first attempt whenever the sky has been sufficiently clear Also, since the sun's image from the siderostat feeding the object glass rotates during the day, the spectrograph slit becomes tangential to the sun at different latitudes in the course of the day, but evidence of the reversal of the oxygen lines was secured always It is therefore clear that the reversals have not been seen once only at a favoured region of the sun's limb, but are a permanent feature of the whole chromosphere

The length of the reversed oxygen lines obtained with a straight slit tangential to the sun's limb is a measure of the height to which oxygen (as represented by this triplet) extends in the chromosphere The height deduced from the photograph reproduced in fig B is 3 5″ This is very likely an underestimate, since the limb of the sun was probably a little distance from the slit at its nearest point, in order to avoid the risk of photospheric light entering the spectrograph Under the best conditions of observation and in eclipse photographs it is to be expected that the oxygen lines will extend to greater heights than this.

One other point should be mentioned At the time of observation and at the position on the sun's limb at which the photograph reproduced in fig B was taken, there was no prominence at the sun's limb

Since the oxygen triplet at λ 7770 has a high excitation potential, it follows that if they are observed at all in the chromosphere, the number of atoms in the ground state must be large Russell has shown [1] that at solar temperatures the number of oxygen atoms in the ground state is of the order of 10^8 times those which can emit the triplet at λ 7770 Consequently we may conclude that oxygen is extremely abundant in the sun's chromosphere Russell has stated [1] that although there is some uncertainty regarding the proportions of non metals in the reversing layer of the sun, it would appear that the proportions of elements (by volume) in the reversing layer are H 91 per cent, He 3 per cent, O 3 per cent, all metals 1 5 per cent Since oxygen is therefore of great abundance in the reversing layer of the sun, it is not surprising that it is also to be found in the chromosphere, and by the same arguments as Russell's for the reversing layer, it follows that if the infra-red triplet of high excitation potential is seen at all, the abundance of oxygen in the chromosphere must be large

As is well known, Milne's theory of radiation pressure on the atoms of ionised calcium as the support of a chromosphere is the only theory which has even partially explained the phenomena of the sun's chromosphere It has successfully explained the great height reached by calcium in the chromosphere, the possibility of the formation of calcium prominences and the origin of the large velocities of ascent in eruptive calcium prominences It is also well known[2] that there are very serious objections to Milne's theory The strongest

[1] Russell, A J 70 11. 1929.

[2] Royds, Kodaikanal Observatory Bulletin No 95 287 1932 and others

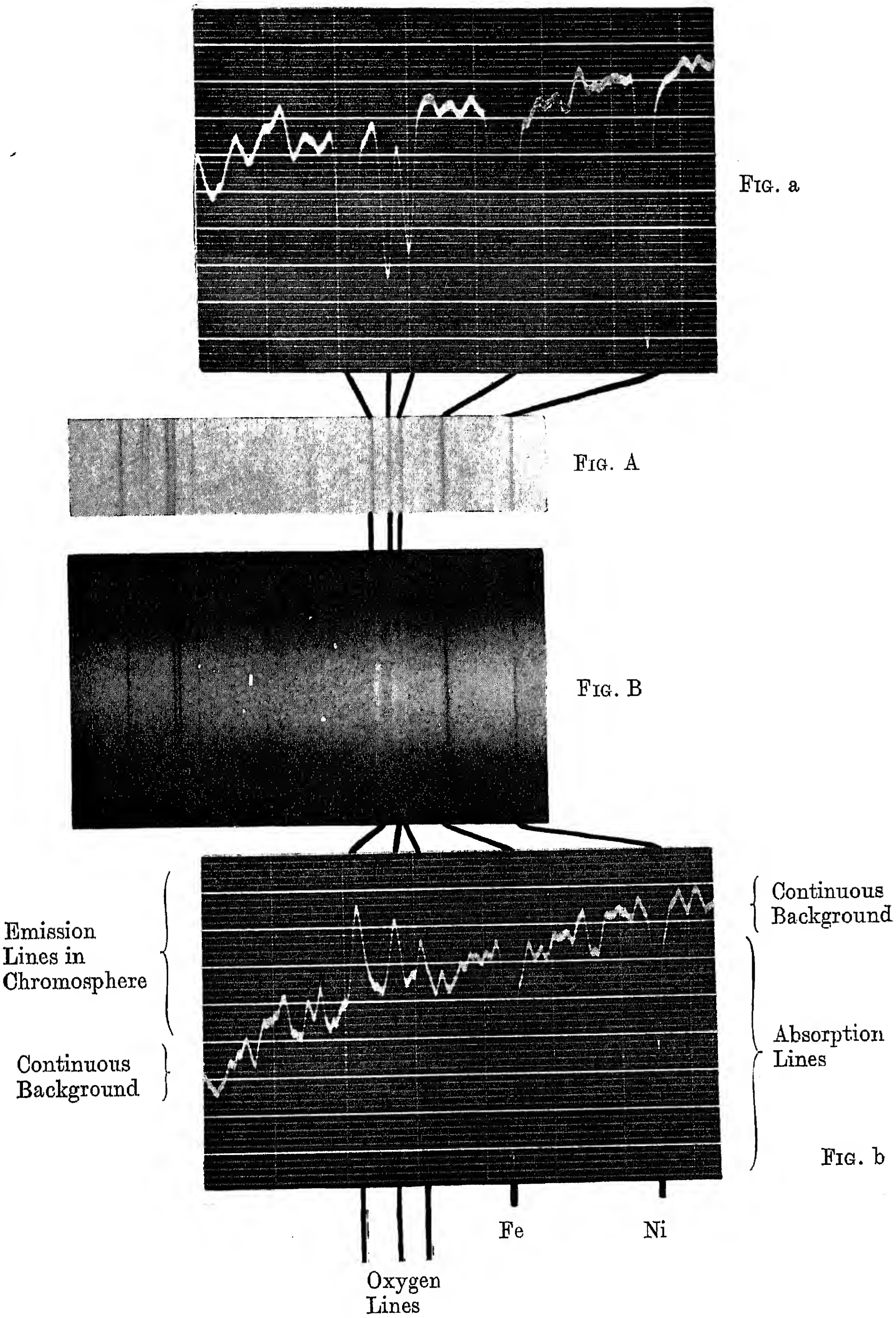


FIG. a

FIG. A

FIG. B

FIG. b

Fig. B shows bright Oxygen lines in Chromosphere.

Fig. A shows ordinary solar spectrum.

Fig. a and b are photometric records of A and B.

objection is that the chromosphere contains other elements which are present in far greater abundance than calcium. To the previously known presence of hydrogen and helium we have now the presence also of oxygen. All these three elements are present in great abundance, indeed they are, as mentioned above, the three most abundant elements in the sun. Yet the selective radiation pressure on all three is insignificant. It would seem therefore that mere abundance in the reversing layer is an important factor for the presence of an element in the chromosphere. Whatever may be the nature of the force which supports the sun's chromosphere containing H, He, O and Ca^+, it might be that the function of radiation pressure is to raise the calcium atoms to that high level where the chromospheric supporting force begins to be effective, rather than that the radiation pressure effective on ionised calcium alone is in some way enabled to drag with it into the chromosphere enormous quantities of H, He and O.

The presence of neutral potassium and rubidium in the chromosphere is not to be expected on account of their low ionisation potentials. The most favourable lines for detecting their presence are their resonance lines and it so happens that these lines lie near the oxygen triplet, so I have looked for them. I have not been able to detect any suspicion of bright lines of K at 7698, Rb at 7800, nor the subordinate lines Rb 7757 and 7619.

For the formation of the sun's image in this research, use has been made of a 15″ object glass loaned by the Nizamiah Observatory to whom I express my indebtedness.

KODAIKANAL OBSERVATORY,

29th August 1935.

T. ROYDS,

Director, Kodaikanal Observatory.

GIPD--M 127 Dr Kodaikanal Obs--29-1-36--370.

Kodaikanal Observatory.

BULLETIN No. CVIII.

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE FIRST HALF OF THE YEAR 1935.

In pursuance of the programme of work adopted since 1st January 1923 under the auspices of the International Astronomical Union, all observatories taking spectroheliograms of the sun have been asked to co-operate with the Kodaikanal Observatory by supplying copies of their photographs for those days when the Kodaikanal records are imperfect or wanting. In response to our requirements for the first-half of the year 1935, the Mount Wilson Observatory supplied calcium (K_{232}) prominence plates for 19 days and H_α disc plates for 15 days and the Meudon Observatory supplied calcium (K_3) disc plate for 1 day and H_α disc plates for 10 days.

When only incomplete or imperfect photographs for any day are available from more than one observatory the best photograph is chosen as representing the solar activity of that day, after weighting it according to its quality, and the remaining photographs are ignored.

Calcium Prominences at the Limb.—The mean daily areas and numbers of prominences photographed during the half-year by means of the K line of calcium are given below. The means are corrected for incomplete or imperfect observations, the total of 177 days for which plates were available being reduced to 163 effective days.

	Mean daily areas (square minutes)	Mean daily numbers.
North	1·99	6·81
South	2·49	6·77
Total .	4·48	13·58

Compared with the previous half-year, areas and numbers show an increase of 14 per cent. and 2 per cent. respectively.

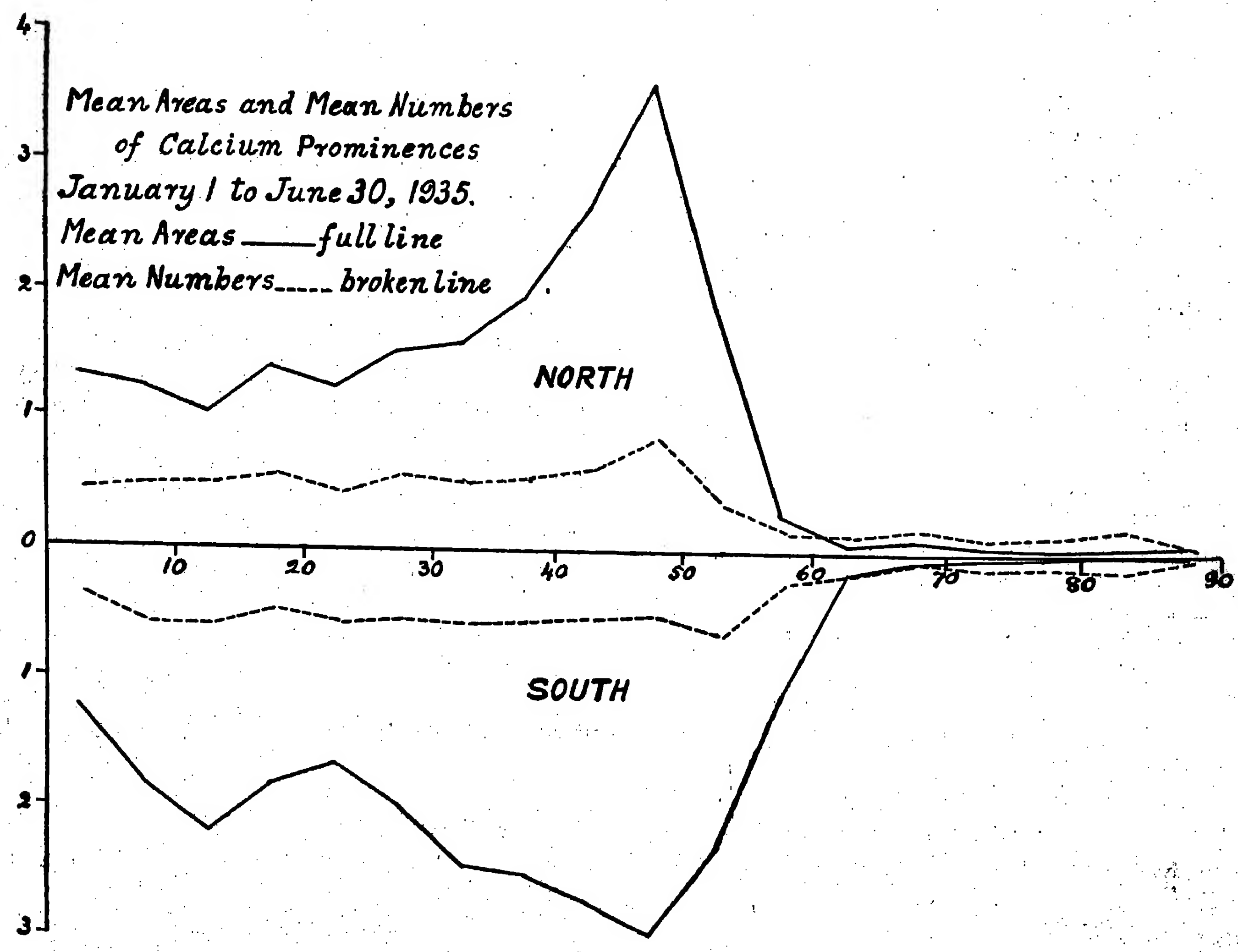
For comparison with bulletins issued prior to the co-operation of other observatories the means based on Kodaikanal photographs alone are also given, 167 days of observation being counted as 155½ effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North (Kodaikanal photographs only)	2·01	6·80
South (do.)	2·50	6·86
Total .	4·51	13·66

Price annas 5 or 6d.

The distribution of prominences in latitude is represented in the following diagram, in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude. The ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line.

The general increase in prominence activity observed in the previous half-year is maintained. Compared with the second-half of 1934, there has been increased activity in the belts 10° to 15° and 30° to 40° in the southern hemisphere. The maximum of activity as seen in areas remains stationary in the belt 45° to 50° in both the hemispheres, while the maximum in numbers has advanced 5° towards the poles in the southern hemisphere.



The monthly, quarterly and half yearly areas and numbers and the mean height and the mean extent of the prominences on photographs from all co-operating observatories are given in Table I. The unit of area is 1 square minute of arc. The mean height is derived by adding together the greatest heights reached by

individual prominences and dividing by the total number of prominences observed, the mean extent is derived by adding together the lengths of the base on the chromosphere of individual prominences and dividing by the total number of prominences.

TABLE I.—ABSTRACT FOR THE FIRST HALF OF 1935.

Months.	Number of days (effective).	Areas.	Numbers.	Daily means. Areas.	Daily means. Numbers.	Mean height.	Mean extent.
1935.							°
January	25½	112·5	339	4·4	13·3	37·0	4·96
February	27¼	121·2	409	4·5	15·0	33·5	4·60
March	28¾	128·2	396	4·5	13·8	33·8	5·26
April	26¼	122·4	369	4·7	14·1	32·2	5·20
May	28¾	134·8	348	4·7	12·1	36·9	6·35
June	26½	112·9	352	4·3	13·3	35·7	5·38
First quarter . . .	81½	361·9	1,144	4·4	14·0	34·6	4·95
Second quarter . . .	81½	370·1	1,069	4·5	13·1	34·9	5·67
First-half	163	732·0	2,213	4·5	13·6	34·8	5·29

Distribution East and West of the Sun's Axis.

Compared with the previous half-year, both areas and numbers show a very slight defect in the east limb as will be seen from the following table :—

1935, January to June.	East.	West.	Percentage East.
Total number observed	1,094	1,119	49·44
Total areas in square minutes	365·0	366·0	49·93

Date		Hour IST		Latitude		Limb	Displacement			Remarks
				North	South		Red	Violet	Both ways	
		H	M	°	°		A	A	A	
April	1	8	50	68		E		Slight		In chromosphere
	4	9	32		13 5	E	Slight			Do
	5	9	28		47 5	W			Slight	
	10	10	22		24	E	2			At base
		10	22		27	E	1			Do
		10	22		29	E		1		At top
		11	17		43	E	1			Throughout the height extending over 3°
		11	40		60	E	1			Throughout the height extending over 11°
	15	11	14		58 5	W	0 5			At base
		11	10		18 5	W	1			At top extends over 3° from —17° to —20°
	23	8	46	62 5		W			Slight	
	28	9	16		34 5	W	2 5	Slight		At top
	29	9	57	46		W				In chromosphere
	30	8	55	44		E	Slight			At top
May	2	9	37	48		E	1 5			At top extends over 2° from +47° to +48°
	3	9	19		30	E	Slight			Extends over 2° from —29° to —31°
		9	19		32 5	E		Slight		
	4	9	37		24	E		1		At top
		9	37		28	E		Slight		Do
		9	24		29	E	Slight			In chromosphere
	7	9	32		15 5	E	0 5			At base
	8	9	27		50	E		Slight		At top
	10	9	10	31		E			2	
		9	01		6 5	W	Slight			At top
	11	10	00		29	W		3		In chromosphere
		10	00		25	W		2		At base
		10	00		17 5	W		2		At top extends over 5° from —15° to —20°
	12	8	58		37	W		1		At top, extends over 4° from —35° to —39°
		8	58		33	W	1			At base extends over 2° from —32° to —34°
	13	9	42		38	W	3			At base
		9	42		32 5	W	2 5	1 5		To red at base and to violet at top
	14	10	15		4 5	E	Slight			At top
	18	10	8		30	W		Slight		At base
	22	9	35		55	E	Slight			In chromosphere
	29	9	29	25		E	Slight			At base
	30	9	04	84		E	Slight			At top
June	1	10	46		71	W	2			At top
	4	9	15		45	E	Slight			At top extends over 2° from —44° to —46°
		9	00	7		W	Slight			At top
	7	9	07		20	E		Slight		At top extends over 2° from —19° to —21
		9	09		25	E	Slight			At base
		9	10		31 5	E			Slight	Extends over 2°
	8	10	05		23 5	W	1			At top

The total number of displacements was 91 as against 45 in the previous half-year, and their distribution was as follows :—

	North.	South.
1° to 30°	8	34
31° to 60°	10	28
61° to 90°	7	4
Total	25	66

East limb	41
West limb	50
Total	91

Of these displacements, 56 were towards the red, 29 towards the violet and 6 both ways simultaneously.

Reversals and displacements on the Sun's disc.

One hundred and seventy-three bright reversals of the $H\alpha$ line, 139 dark reversals of the D_3 line and 14 displacements of the $H\alpha$ line were observed during the half-year. Their distribution is given below :—

	North.	South.	East.	West.
Bright reversals of $H\alpha$	70	103	99	74
Dark reversals of D_3	56	83	78	61
Displacements of $H\alpha$	7	7	7	7

Five displacements were towards the red, five towards the violet and four both ways simultaneously.

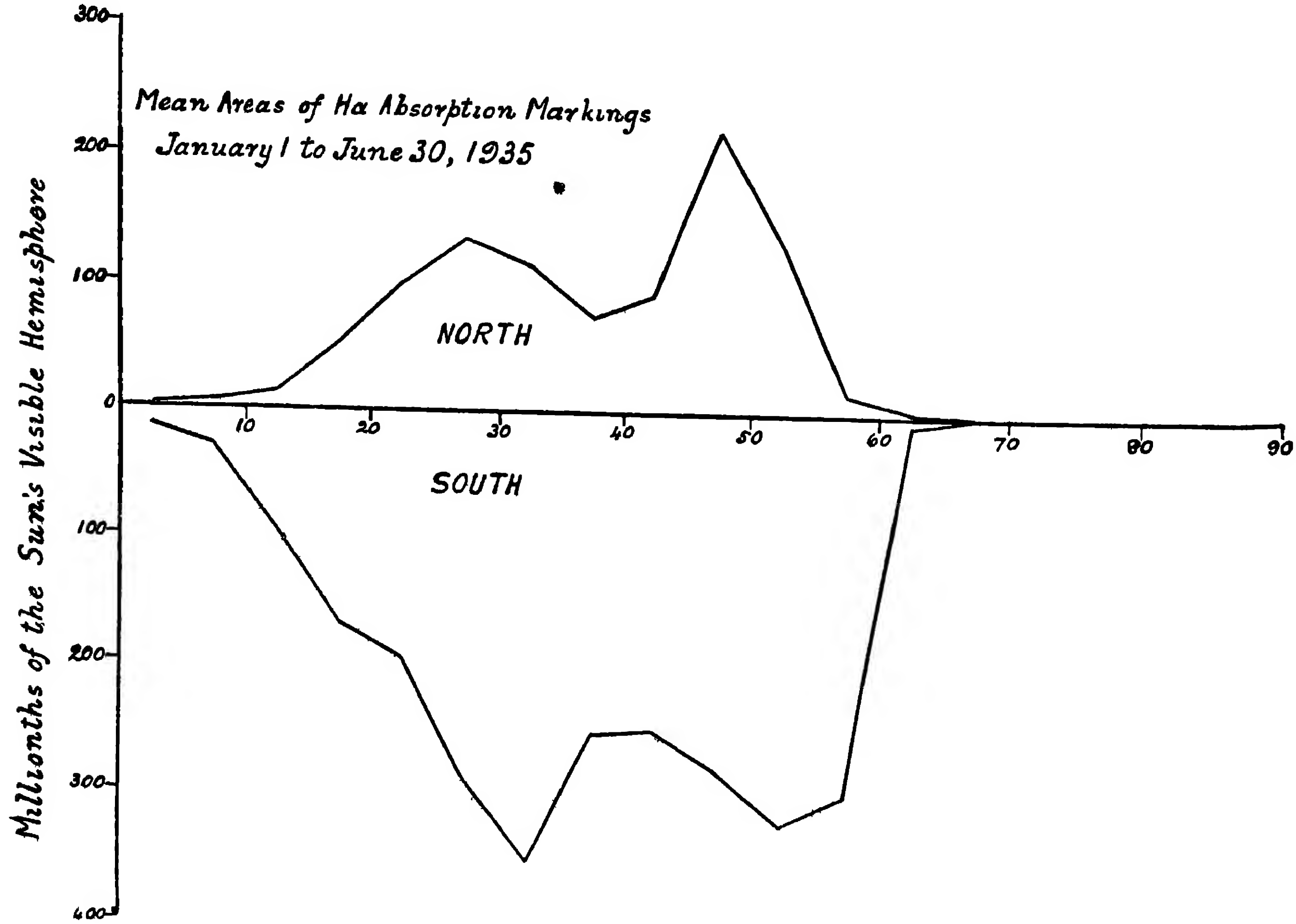
Prominences projected on the Disc as Absorption Markings.

Photographs of the sun's disc in $H\alpha$ light were available from Kodiakanal and the co-operating observatories for a total of 178 days which were counted as 168 effective days. The mean daily areas of $H\alpha$ absorption markings (corrected for foreshortening) in millionths of the sun's visible hemisphere and their mean daily numbers are given below :—

	Mean daily areas.	Mean daily numbers.
North	959	6·22
South	2,521	13·11
Total	3,480	19·33

The distribution of mean daily areas in latitude is shown in the following diagram. Compared with the previous half-year, there has been great increase in activity in the southern hemisphere, the activity in the northern hemisphere remaining almost the same as in the previous half-year. The maximum of activity in the

zone 45° to 50° noted in the two previous half years remains in the same zone in the northern hemisphere and has advanced 5° towards the pole in the southern hemisphere, where a second maximum has also appeared in the belt 30° to 35°



Compared with the previous half year both areas and numbers show a slight eastern defect, the percentage in areas being 48 6 and in numbers 49 0

The mean daily of Hα areas absorption markings uncorrected for foreshorting are given below —

		Mean daily areas
North		511
South		1 354
	Total	1,865

The uncorrected areas amount to 54 per cent of the corrected ones

The curve of distribution in latitude is similar to that for the corrected areas as usual

Thanks are due to the co operating observatories for the photographs supplied by them

KODAIKANAL,
29th March 1936

A L NARAYAN,
Assistant Director, Kodaikanal Observatory.

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Kodaikanal Observatory.

BULLETIN No. CIX.

PHOTOMETRIC STUDY OF THE LINES OF HYDROGEN AND OF CALCIUM IN THE FRAUNHOFER SPECTRUM AT DIFFERENT POINTS OF THE SUN'S DISC,

BY

T. ROYDS AND A. L. NARAYAN.

SUMMARY.

By means of photographic photometry, the contours of several strong lines in the sun's spectrum have been obtained for various points of the sun's disc between the centre and the limb, and the equivalent widths have been derived from the contour curves. The lines studied were Hα, Hβ, Hγ, Hδ, the H and K lines of ionised calcium and the 4226 line of neutral calcium.

It is found that the residual intensities in every part of all the lines studied are greater as the limb is approached than at the centre of the disc. This is consistent with our previous knowledge of the tendency of the wings of lines to disappear towards the sun's limb, but the common appearance of lines becoming wider at the limb is partly due to the relative insensitiveness of the eye to the faint wings, for actually both in the core and in the wings the residual intensity is always (for the lines studied) greater towards the limb.

The residual intensities, equivalent widths and corresponding number of atoms lying above 1 cm^2 of the sun's surface are given for different points on the sun's disc in Tables I to VII.

It is of interest to compare the effects of the greater inclination to the vertical of the path through the atmosphere for the case of terrestrial lines produced by the earth's atmosphere, with the limb effect for solar lines. Using 9 lines of the B band due to terrestrial oxygen it was confirmed that their equivalent width increases proportionately to the square root of the number of absorbing molecules, the residual intensity in the lines being decreased at all points of the contour with increasing zenith distance. In the sun the effect is in the opposite direction as the inclination of the path through the reversing layer increases (as occurs towards the limb), and the difference is due to the fact that near the limb of the sun the effective level of the photosphere is higher than at the centre of the disc, whereas in the case of terrestrial lines the background of continuous spectrum is unchanged for both high and low sun.

The change in contour of solar lines as the limb is approached is the combination of two opposite effects, namely (1) an increase in the number of effective atoms due to the greater length of path when it is inclined to the vertical, tending to strengthen the line and increase its equivalent width, and (2) a decrease in the number of atoms due to the fact that the effective level of the photosphere is higher at the limb, tending to weaken the line and decrease its equivalent width. The first effect can be allowed for from geometric considerations so that the second effect can be measured from the changes in the contours towards the limb. Hence we have derived the concentration of atoms at different levels in the sun's reversing layer as given in Table X.

The electron pressure derived from the ratio of neutral to ionised atoms, is about 2×10^{-5} atmospheres at all the levels considered.

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th numb r of atoms lying above the different l v l and consequently al o giv th l n iti b tw n th
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at the Kodaikanal Observatory of the lin of hydrog n and of calcium in the un s pectrum fr m liff r nt
points on the sun s disc the results of which are reported in this bulletin

The spectrograph employed was the larg grating p ctrograph of the Ob rvatory whi h ha b n l
crib l elsewhere[3] Briefly this pe tr graph u a larg plan grating and it cam ra whi h ha a f al l ngth
of 13½ feet lies at an angle of about 60 to the collimator Th li p r ion of the pe tr graph in th r i n
u ed in this research were as follow —

Hα	(l l)	l l A p n
Hβ	(3 l l)	
Hγ	( )	
λ 4 26	( )	
Hδ	( )	
H & K	( )	1 83

Special care was taken to reduce the int rnal att ring within th p ctr graph by tra rad f r
possible of internal refle tion Spectrogram have been obtained u ing a Mich l on plan grating a l al
using a Rowland plane grating With the Michelson grating it wa n ce ary to cut l wn b th th a th
the length of the ruling in order to obtain the be t definiti n The r ult from th t o gratin l n a l l r
systematically and the averages for the two have been taken

The sun s image was formed by a 1 object gla (kindly loane l to thi Ob rvat r N
Observatory Hyderabad) fed from an 18 siderostat The diameter f the un ima wa a

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Minnaert and Houtgast Z f Astrophysik 1 81 1936 Th s p p r ppea l ft tl r
ti n s lt l a l interpr te l fr m an ntirely liff rent p i t f vi w
[3] Hale & Adams A J 25 300 1907
Kodaikanal Observatory Bulletin 36 45 1913

The sun's image was formed on a plate which could be displaced horizontally immediately in front of the vertical slit of the spectrograph. On this plate concentric circles were inscribed to facilitate accurate guiding of the sun's image which was kept concentric with the circles. In order to obtain the spectra from different points of the sun's disc, a series of small holes had been drilled along a horizontal diameter of the circles, and their positions relative to the circles accurately measured. By displacing the slit plate horizontally so as to bring any of these holes exactly central on the slit of the spectrograph, the sun's image being also displaced to be concentric with the inscribed circles, different points on the sun's disc from the centre of the disc to the limb could be photographed. Generally, eight different points between the centre of the disc and the limb were obtained on the same photographic plate, the point nearest the limb being as close to the limb as could be accurately measured and maintained.

The standardising spectrum for photometry was obtained on the same plate as the spectra to be studied and with identical exposures. In order to ensure uniform illumination along the whole length of the slit for the standardising spectrum, the object glass was temporarily removed so that parallel light from the siderostat fell on the slit, in front of which was placed a calibrated step wedge. As a check, a standardising spectrum was also obtained by means of a step wedge immediately in front of the photographic plate. So that the standardising spectrum could have suitable densities with the same exposure as the spectra to be measured it was necessary to obtain the former with the first or second order spectrum when the latter were obtained with the second or third order respectively.

The photometric measures were made with the Cambridge pattern microphotometer which, after the necessary experience had been gained, was found to give reliable measures when proper precautions are taken. The effective width of the photometer slit was about 0·005 A so that the loss of resolving power in the photometer was insignificant.

No reliance can be placed on photographic photometry unless certain essential precautions are taken. In making the photometric studies reported on in this bulletin, the two following precautions were rigorously adhered to. Firstly, equal exposures were given to the standardising spectrum and those to be measured photometrically by comparison with it: the standardising spectrum was exposed on the same plate which was developed with a brush in order to minimise the Eberhard effect. Secondly, the standardising step wedges were calibrated under exactly the same conditions as those in which they were used. This is most important at any rate for the type of wedge which has been used in this investigation. The wedges used were made by suitably exposing strips of a photographic plate. Photographically prepared wedges have the advantage that they can easily be made of sizes and densities to suit the object in view, but they have one great disadvantage in their graininess. This graininess introduces a very serious difficulty in their use. It is well known that the density of a medium depends on the optical arrangements when it is used. A wedge whose density values have been measured in one instrument cannot be used with these values in another instrument, nor used in another position in the same instrument. It was found, for instance, that when a wedge was used immediately in front of the photographic plate it gave entirely different densities from those when the same wedge was used in front of the spectrograph slit. This effect is considerable for photographically prepared wedges. The photographically prepared wedges used in this investigation were standardised in two ways for each optical arrangement in which they were used. One was by means of perforated screens with known ratios of the apertures of the perforations, and the other was by comparison with standard Ilford wedges used under conditions similar to those for which the maker's certificate was obtained. The values obtained in these two ways were consistent with each other. Two step wedges were used, each with 10 steps ranging from clear glass to the greatest density which was found necessary. One step wedge was used immediately in front of the photographic plate and the other was used immediately in front of the slit of the spectrograph. In order to illustrate the

[illegible] of [illegible] wedges in these two different positions the values of their transparencies for a wavelength of 4100 Å are given in the following table: —

TRANSPARENCIES OF SIMILAR STEP WEDGES FOR λ 4100

	Step Wedge [illegible] used in front of plate	Step Wedge [illegible] used in front of slit
Step 1	100	100
[illegible]	9[illegible]	[illegible] 3
3	87 7	89 3
4	81 7	[illegible]0 8
[illegible]	63 1	41 [illegible]
6	44 1	[illegible]1
[illegible]	31	14 [illegible]
8		[illegible] 1
9	1 3	[illegible]
10	1 1	3 [illegible]

If the two wedges referred to had been used in similar positions their transparencies would [illegible] similar (although not identical for they were constructed independently of each other) but the [illegible] shows how different are their effective transparencies due to their different positions in the [illegible] arrangement. Yet in the results obtained there was satisfactory agreement in the [illegible] values [illegible] with [illegible] wedges in these two different positions.

The theory of the formation of absorption lines has been formulated many times. We shall [illegible] the method of Unsöld[4] who was the first to deduce the number of absorbing atoms in stellar atmospheres [illegible] showed that absorption lines could be accounted for by the scattering effect of the [illegible]. He made use of the value of the selective scattering coefficient given by Voigt from the classical theory [illegible] by bound electrons, namely

$$\sigma = \frac{2\pi e^{4}}{3 m^{2} c^{4}} \cdot \frac{\lambda^{2}}{(\lambda - \lambda_{0})^{2}} \cdot N f \qquad (1)$$

where σ is the scattering coefficient per cm length

λ is the wavelength at the centre of the absorption line

N is the number of absorbing atoms per c.c.

f is the oscillatory strength for the particular line

and the remaining terms have their usual significance.

The above expression only applies in the absence of Doppler broadening due to the [illegible] ing atoms in the line of sight, in the absence of collisions between the atoms [illegible] and in the absence of the Stark effect due to interatomic electric fields. In the presence of Doppler [illegible] expression may only be strictly applied to the wings of the absorption line sufficiently far from [illegible] unaffected by the Doppler displacements which come into consideration.

[4] Unsöld, Z. f. Phys., 44, [illegible]; Z. f. Phys., 46 [illegible]

No exact expression has yet been given for the contour of an absorption line produced by an atmosphere of finite thickness. The best that can be done is to use approximations made under simplifying assumptions. Schuster showed that if we assume a definite photospheric surface at the base of a homogeneous scattering atmosphere, the contour of the resulting absorption line will be given by

$$r = \frac{1}{1+\sigma H} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where r is the ratio of the intensity in the line to the intensity of the photospheric radiation,

σ is the scattering coefficient of the atmosphere,

and H is the height of the atmosphere.

Substituting Unsöld's expression for the scattering coefficient, it will be seen that the contour of an absorption line broadened by scattering will be of the form

$$r = \frac{1}{1+\alpha/(\lambda-\lambda_o)^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where $\alpha = 2\pi e^2\lambda_o{}^2 NfH/3m^2c^4$.

The actual contours found for Fraunhofer lines do not follow the above form for r. Neither the contours which are published in this bulletin nor those which have been published by others resemble that given by the above equation (3). Unsöld and others have sometimes interpreted their results by taking the widths of lines at a certain value of r. This corresponds to selecting a point on the actual contour where it is cut by the theoretical contour given by (3). Naturally, the results obtained will depend on the value of r selected.

Also, the intensity at the centre of an absorption line predicted by equation (3) is not verified in the actual measures of absorption lines in the sun and stars. According to equation (1) the scattering coefficient at the centre of the line, where $(\lambda-\lambda_o)$ is zero, is infinitely large and therefore the absorption of photospheric radiation should be complete, making the central intensity zero. Actually it is found that the central intensities in Fraunhofer lines are considerable, being of the order of at least 10 per cent even for strong lines. It should be mentioned, however, that since the work published in this bulletin was completed, Thackeray,[5] using a monochromator in front of the slit to reduce scattering in the spectrograph, has found much smaller central intensities particularly for the resonance line of neutral calcium, λ 4226. If the results of Thackeray are correct, they remain difficult to explain. Some attempts have been made by Woolley [6] and by Strömgren [7] to interpret the appreciable intensities found at the centre of Fraunhofer lines as fluorescence effects in the manner suggested by Rosseland. Whether these interpretations are well based or not, it is difficult to see why the calcium line 4226 should have the lowest central intensity as found by Thackeray. Whatever may be the processes in stellar and solar atmospheres which cause appreciable intensities in other lines, it is not easy to see why λ 4226 line should be an exception.

The evidence of the central intensity in the terrestrial lines in the Fraunhofer spectrum should not be neglected. It is shown later in this bulletin that the lines in the Fraunhofer spectrum which are most certainly conditioned solely by pure scattering are lines in the terrestrial bands due to absorption by gases in the earth's atmosphere. Take for instance the B band due to molecular oxygen. If any lines in the Fraunhofer spectrum should have the zero central intensity predicted by the scattering theory, they are lines such as those of the B band, the photometric results for which are given in a later section of this bulletin. Anticipating the results there given, we may state that the central intensities of the lines examined are of the order of 40 per cent of the sun's continuous spectrum. This deviation from the predicted zero value is so considerable that there is no possibility of explaining it as due to defective experimental conditions such as internal scattering within the spectrograph.

Notwithstanding the abovementioned discrepancies between the contours actually found in the Fraunhofer spectrum and those expected from the theory of scattering considerably more confidence has been placed in the equivalent widths of absorption lines than in the deductions from actual contours. The equivalent width of an absorption line is defined as the width of continuous spectrum which would contain the same energy as the total energy absorbed in the line. It is expressed by $\int_0^\infty (1-r)\,d\lambda$. In the case where the Doppler widening is small the equivalent width of a line is readily obtained from equation (3) and is given by

$$W = \frac{\pi e^2}{mc^2}\,\lambda^2\,\sqrt{\frac{2\pi}{3}}\,\sqrt{N f H} \qquad (4)$$

If the Doppler widening is large enough to be the principal agent in broadening an absorption line the equivalent width is given by[8]

$$W = \frac{\pi}{mc^2}\,\lambda^2\,N f H \qquad (5)$$

Actually neither (4) nor (5) corresponds to solar conditions for the wide lines which we are considering in this bulletin. Under actual conditions where the Doppler widening is not negligible but not large enough to be the controlling agent we can only regard (4) as an expression for the upper limit of NfH and (5) as the lower limit. It must also be noted that Unsold has shown[9] that for the oscillatory strengths f terms which he has designated by f should be used. He has calculated the f values for Hα, Hβ and Hγ. For resonance lines such as the H & K lines of Ca+ and the 4226 line of Ca the f value are the same as the oscillatory strengths.

The lines of the B band in the Fraunhofer spectrum have been variously used[10] for the verification of the expression (4) for the equivalent widths of absorption lines as a function of the number of absorbing atoms when the lines are produced by pure scattering. In the case of Fraunhofer lines due to absorption in the earth's atmosphere the Doppler widening, the effect of atomic collisions and the Stark effect can all be assumed to be negligible and we have in these lines an ideal case of absorption lines produced by pure scattering. The number of effective atoms varies with the altitude of the sun. All that is necessary for the tests is therefore to make photometric measures of spectrum photographs taken at high and low altitudes of the sun preferably on the same day. As the previous results of different observers were not in exact agreement measures of some of the lines in the B band have been made at the Kodaikanal Observatory in view of the importance of the matter. Photographs were taken of the B band with the sun at a zenith distance of 72° and at a zenith distance of 23° each with its own standardising spectrum for photometry. The lines chosen for measurement were the nine lines from λλ 6877.650 to 6870.959. Two photographs were taken at low altitude. For zenith distances up to 72° the lengths of the paths through the air and consequently the number of absorbing atoms may be assumed to be proportional to the secant of the zenith distance. It is sufficient to quote the mean for the above 9 lines.

Ratio of equivalent widths for low and high sun	1.4
Ratio of secants of zenith distances	1.0

This result shows that the proportionality of the equivalent width to the square root of the number of absorbing atoms is actually realised when the lines are conditioned by pure scattering. Although the results confirm the scattering theory in showing that the equivalent widths of the lines of the B band are proportional to the square root of the number of scattering atoms yet the central intensities in these lines are very different from the zero value predicted by the theory of scattering. With high sun the central intensities of the 9 lines measured average 42 per cent of the continuous background and with low sun 26 per cent. Since absorption in the earth's atmosphere fulfils almost ideally the conditions required for the application of the theory of absorption by scattering and yet shows appreciable central intensities in the absorption lines it would seem that the central intensities in the Fraunhofer line may be due to the defects of the scattering theory rather than to obscure physical processes in the reversing layer.

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8 ... and El... ey, Z. f. Astrophysik 1, 314, 1930.

9 Unsold, St...

10 ... Z. f. Astrophysik, 2, 199, 1931; ... Phil. Mag. 14, 1047, 1932.

The photometric results for the various lines studied at the Kodaikanal Observatory are given below i Tables I to VIII and in figs. 1 to 8, which are the averages from 5 or more plates. Since it was desirable t

TABLE I.—CALCIUM LINE λ 4226.

Residual intensity, Equivalent width, and Number of atoms above 1 cm² of photosphere.

Sin θ*	0	0·44	0·65	0·77	0·86	0·95	0·98
Cos θ	1·0	0·898	0·760	0·638	0·510	0·312	0·199
$(\lambda - \lambda_0)$§							
0	16·9%	18·8%	18·3%	18·8%	19·6%	20·9%	22·1%
± 5†	20·8	22·0	22·7	23·4	24·2	26·2	26·9
± 10†	26·2	27·8	28·3	29·9	31·6	35·1	36·7
± 15	31·6	33·8	33·7	36·6	37·2	42·2	44·8
± 20	37·7	39·7	38·7	41·0	42·5	47·9	50·9
± 25	44·1	45·9	45·6	46·4	47·3	51·9	55·3
± 30	50·5	51·1	49·1	51·4	51·6	55·8	59·2
± 35	54·5	55·7	53·6	55·3	55·1	58·8	62·3
± 40	58·0	59·4	57·1	58·3	58·4	61·4	64·7
± 45	60·9	61·9	59·9	61·0	60·6	63·4	66·7
± 50	63·2	64·2	62·2	63·3	63·4	65·5	68·6
± 60	67·7	68·5	66·6	68·2	67·6	69·8	72·0
± 70	72·3	72·6	71·1	73·3	72·0	74·0	75·8
± 80	78·4	78·7	76·2	78·0	77·9	79·1	79·3
± 90	85·2	82·8	81·5	82·9	83·3	83·8	83·0
±100	87·5	85·1	84·6	86·0	86·3	87·7	86·1
Equivalent width	1·35 A	1·33	1·40	1·35	1·34	1·24	1·21
** NH per cm²	$3·10 \times 10^{16}$	3·02	3·35	3·09	3·05	2·64	2·49

* Sin θ = distance from centre of disc expressed in radii.

§ 100 units = 1·57 A, or 1 A = 63·6 units.

† Contours for intermediate points near centre of line were determined but are not here reproduced.

** By formula (4); f = 2, ∴ $NH = W^2 \times 10^{16}/0·587$.

Table II.—H Line of Ionised Calcium.

Residual intensity, Equivalent width, and Number of atoms above 1 cm² of photosphere.

Sin θ*	0	0·44	0·65	0·77	0·86	0·95	0·98
cos θ	1·0	0·898	0·760	0·638	0·510	0·312	0·199
$\Delta\lambda$ § r							
0	14·4%	15·4%	16·4%	17·4%	16·6%	21·1%	22·6%
± 5 †	19·5	21·1	22·0	23·9	23·0	28·6	30·0
10 †	24·4	26·7	27·2	29·9	29·6	37·2	38·2
± 15	28·3	31·4	31·3	34·2	33·4	42·1	44·3
20	32·6	35·2	35·6	38·6	37·0	45·9	49·0
30	41·8	44·2	43·8	47·5	44·3	54·2	57·0
40	51·0	54·0	53·6	56·2	53·7	61·7	64·9
± 50	59·2	63·2	62·5	63·5	59·6	69·0	70·2
± 60	66·2	70·3	68·2	69·3	65·6	73·6	73·8
± 70	76·0	75·7	74·6	75·0	69·5	78·0	78·7
± 80	81·3	81·5	81·1	83·0	74·3	82·6	82·4
Equivalent width	8·91 A	9·20 A	8·88 A	9·28 A	9·38 A	7·82 A	6·81 A
** NH per cm²	$9{\cdot}30 \times 10^{18}$	9·93	9·25	10·10	10·34	7·17	5·44

* Sin θ = distance from centre of disc expressed in radii.

§ 100 units = 8·25 A, or 1 A = 12·1 units.

† Contours for intermediate points near centre of line were determined but are not here reproduced.

** By formula (4); f = 1/3, ∴ NH = $W^2 \times 10^{18}/8{\cdot}53$.

Table III.—K Line of Ionised Calcium.

Residual intensity, Equivalent width, and Number of atoms above 1 cm^2 of photosphere.

Sin θ*	0	0·44	0·65	0·77	0·86	0·95	0·98
Cos θ	1·0	0·898	0·760	0·638	0·510	0·312	0·199
$(\lambda-\lambda_o)$ §							
0	14·0%	15·2%	16·7%	16·9%	18·2%	20·3%	21·2%
± 5 †	18·2	19·0	20·6	21·4	23·2	25·6	28·0
±10 †	22·0	23·0	24·9	26·2	28·3	31·3	33·6
±15	25·2	26·2	28·4	30·1	32·6	35·5	38·8
±20	28·4	29·4	31·8	33·3	36·1	40·8	43·0
±30	35·2	35·4	37·9	39·2	42·1	47·8	50·8
±40	42·5	42·6	45·1	46·0	48·3	53·1	57·5
±50	50·1	49·6	51·8	52·5	54·6	58·9	64·0
±60	58·2	57·5	59·2	59·6	61·5	64·4	69·5
±70	66·4	66·2	67·3	67·1	68·1	70·0	74·6
±80	71·8	72·4	73·8	73·3	71·1	73·1	79·2
Equivalent width . . .	10·77 A	10·74	10·60	10·44	10·09	9·68	8·54
** NH per cm^2 . . .	$10\cdot85\times10^{18}$	10·80	10·51	10·20	9·53	8·78	6·83

* Sin θ = distance from centre of disc expressed in radii.

§ 100 units = 8·32 A, or 1 A = 12·0 units.

† Contours for intermediate points near centre of line were determined but are not here reproduced.

** By formula (4); f = 2/3, ∴ NH = $W^2\times10^{18}/10\cdot69$.

Table IV.—Hα Line.

Residual intensity, Equivalent width, and Number of atoms above 1 cm² of photosphere.

Sin θ *	0	0·44	0·65	0·77	0·86	0·95	0·98
Cos θ	1·0	0·898	0·760	0·638	0·510	0·312	0·199
$(\lambda-\lambda_0)$ §							
0	25·1%	25·4%	26·4%	26·9%	27·9%	29·0%	29·1%
± 5 †	25·8	26·2	27·3	27·8	28·8	30·0	30·0
± 10 †	28·2	28·4	29·8	30·2	30·9	32·2	32·0
± 15	33·0	33·0	34·4	34·5	35·2	36·1	36·0
± 20	41·4	40·4	42·7	42·2	43·4	43·8	43·8
± 25	51·8	51·0	53·7	53·3	53·9	55·5	55·2
± 30	61·0	60·5	64·4	63·6	65·6	68·6	68·4
± 35	67·0	67·6	70·0	71·1	73·4	79·1	79·6
± 40	70·9	71·2	73·4	75·2	77·9	83·8	86·2
± 45	73·3	73·3	75·4	77·8	80·6	86·6	89·1
± 50	75·2	75·2	76·8	79·4	82·4	88·4	90·9
± 60	78·0	78·1	79·8	82·2	85·1	90·7	93·2
± 70	80·6	80·7	82·6	84·2	86·8	92·2	94·6
± 80	82·4	82·2	83·8	85·8	88·1	93·1	95·0
± 90	83·8	83·8	85·7	87·1	89·6	94·0	95·7
± 100	84·8	84·8	86·8	88·4	90·4	94·8	96·2
Equivalent width 0—105	1·56 A	1·56	1·47	1·41	1·31	1·13	1·07
Do. 105—388	0·97 A	0·97	0·85	0·75	0·65	0·31	0·24
Total E. W.	2·53 A	2·53	2·32	2·16	1·96	1·44	1·31
Total number of atoms above cm² of photosphere.	$12·0\times10^{15}$	12·0	10·1	8·71	7·20	3·88	3·20

* Sin θ = distance from centre of disc expressed in radii.

§ 100 units = 2·22 A, or 1 A = 45·0 units.

† Contours for intermediate points near centre of line were determined but are not reproduced.

** By formula (4); f′ = 7·59, ∴ NH = $W^2\times10^{15}/0·536$.

TABLE V.—Hβ LINE.

Residual intensity, Equivalent width, and Number of atoms above 1 cm² of photosphere.

Sin θ *	0	0·44	0·65	0·77	0·86	0·95	0·98
Cos θ	1·0	0·898	0·760	0·638	0·510	0·312	0·199
$(\lambda-\lambda_o)$ §							
0	24·1%	25·7%	26·6%	27·2%	27·0%	28·5%	29·2%
± 5 †	25·6	26·9	27·6	28·2	28·2	29·8	30·3
± 10 †	28·8	29·9	30·9	31·4	31·0	32·6	33·2
± 15	33·4	34·3	35·3	36·0	35·9	37·0	38·4
± 20	39·2	40·0	41·8	42·8	42·7	44·8	46·6
± 25	45·3	46·0	48·0	49·3	49·6	53·4	56·5
± 30	50·9	52·2	54·1	56·0	56·8	62·7	66·0
± 35	56·5	57·6	60·2	61·4	63·8	69·1	72·9
± 40	60·1	61·3	64·0	64·8	67·9	73·3	77·2
± 50	65·4	66·2	69·2	69·9	73·4	78·9	82·4
± 60	68·6	69·2	72·0	74·0	76·8	83·0	85·7
± 70	71·0	71·2	74·5	76·1	79·0	84·9	87·7
± 80	73·0	73·1	76·4	77·2	80·6	86·5	88·5
± 90	75·0	74·9	77·8	78·9	82·1	87·7	89·2
±100	76·8	76·8	79·4	80·0	83·4	89·2	90·2
±120	78·6	79·5	81·4	84·0	84·4	88·8	91·5
±140	81·6	83·0	82·8	82·5	85·6	90·9	92·1
Equivalent width 0—150	1·45 A	1·41	1·33	1·25	1·18	0·995	0·90
Do. 150—800	1·81 A	1·70	1·59	1·45	1·34	0·835	0·70
Total W.	3·26 A	3·11	2·92	2·70	2·52	1·83	1·60
Total number of atoms above 1 cm² of photosphere.	$4·04\times10^{17}$	3·66	3·24	2·76	2·40	1·27	0·97

* Sin θ = distance from centre of disc expressed in radii.

§ 100 units = 1·39 A, or 1 A = 71·8 units.

† Contours for intermediate points near centre of line were determined but are not here reproduced.

** By formula (2) ; f′ = 0·681, ∴ NH = $W^2\times10^{17}/2\cdot64$.

TABLE VI.—Hγ LINE.

Residual intensity, Equivalent width, and Number of atoms above 1 cm² of photosphere.

Sin θ *	0	0·44	0·65	0·77	0·86	0·95	0·98
Cos θ	1·0	0·898	0·760	0·638	0·510	0·312	0·199
$(\lambda - \lambda_0)$ §							
0	28·8%	27·5%	28·3%	28·9%	29·4%	31·6%	34·7%
± 5 †	30·6	29·2	29·8	30·9	31·5	33·5	36·7
± 10 †	35·0	33·4	34·8	35·4	36·8	38·9	44·0
± 15	41·2	40·4	41·9	43·5	45·0	48·4	53·4
± 20	48·0	47·6	48·8	51·4	53·1	58·4	63·6
± 25	53·9	53·6	55·6	58·4	60·8	66·0	72·6
± 30	58·4	58·2	60·6	62·8	65·7	71·7	79·8
± 35	61·3	62·0	63·4	66·0	68·8	74·8	83·2
± 40	63·6	64·2	64·8	68·2	71·0	76·3	84·7
± 45	64·8	65·8	66·0	69·3	72·0	77·2	85·3
± 50	66·2	66·6	67·2	70·2	72·5	78·0	85·7
± 60	68·4	68·8	69·3	72·4	74·2	79·0	86·7
± 70	70·9	71·1	71·4	75·0	76·6	80·6	87·8
± 80	73·6	73·7	73·9	77·2	78·4	82·2	88·8
± 90	77·0	76·2	76·4	80·0	80·6	83·4	90·0
± 100	79·2	79·4	78·8	82·9	83·0	84·8	90·8
Equivalent width 0—105.	1·20 A	1·20	1·18	1·09	1·04	0·90	0·70
Do. 105—400	0·96 A	0·94	0·98	0·78	0·79	0·69	0·43
Total W.	2·16 A	2·14	2·16	1·87	1·83	1·59	1·13
Total number of atoms above 1 cm² of photosphere.	$7 \cdot 92 \times 10^{17}$	7·79	7·92	5·94	5·70	4·50	2·17

* Sin θ = distance from centre of disc expressed in radii.

§ 100 units = 1·52 A, or 1 A = 65·9 units.

† Contours for intermediate points near centre of line were determined but are not here reproduced.

** By formula (4); $f' = 0 \cdot 191$, $\therefore$ $NH = W^2 \times 10^{17} / \cdot 589$.

Table VII.—Hδ Line.

Residual intensity, Equivalent width, and Number of atoms above 1 cm² of photosphere.

Sin θ *	0	0·44	0·65	0·77	0·86	0·95	[illegible]
Cos θ	1·0	0·898	0·760	0·638	0·510	0·312	0·14[illegible]
$(\lambda - \lambda_0)$ §							
0	31·5%	31·8%	33·0%	34·1%	35·7%	41·0%	41·3%
± 5 †	33·1	34·0	35·2	36·9	38·6	44·2	44·2
± 10 †	37·7	38·8	40·2	42·0	44·6	51·8	51·4
± 15	43·2	43·6	45·4	48·2	51·5	61·0	60·6
± 20	48·7	48·2	50·4	53·8	57·3	68·6	68·6
± 25	52·0	52·0	54·2	57·8	61·5	73·4	73·3
± 30	55·2	55·7	57·5	61·2	65·1	76·6	76·6
± 35	58·0	58·4	60·4	64·2	67·4	79·2	78·7
± 40	60·4	61·1	62·2	66·4	70·1	81·0	80·0
± 45	62·4	62·6	64·1	68·2	71·8	82·5	81·6
± 50	64·4	63·7	65·6	69·4	73·8	83·6	82·5
± 60	67·2	66·7	68·2	72·0	76·0	84·8	84·4
± 70	70·1	69·2	70·6	75·0	78·1	86·3	85·4
± 80	71·4	71·1	72·5	76·3	79·5	86·9	85·8
± 90	72·6	71·7	73·4	76·9	79·8	86·1	86·3
±100	72·8	72·1	73·8	77·9	80·3	86·8	86·1
Equivalent width 0–105	1·34 A	1·33	1·28	1·16	1·05	0·76	0·81
Do. 105–235	0·58 A	0·59	0·56	0·47	0·45	0·28	0·29
Total W.	1·92 A	1·92	1·84	1·63	1·50	1·04	1·10
Total number of atoms above 1 cm² of photosphere.	$13 \cdot 4 \times 10^{17}$	13·4	12·3	9·6	8·2	3·9	1·4

* Sin θ = distance from centre of disc expressed in radii.

§ 100 units = 1·604, or 1 A = 62·3 units.

† Contours for intermediate points near centre of line were determined but are not here reproduced.

** By formula (4) ; $f' = 0 \cdot 1$, $\therefore NH = W^2 \times 10^{17}/ \cdot 2755$.

Table VIII.—Mean Contour of 3 similar lines in B band.

Residual intensities expressed as percentages of continuous spectrum.

Distance from centre of line (10 units = 0·219 A).	Secant of Zenith Distance.	
	1·09	3·34
$(\lambda-\lambda_0)$ §		
0	42·1%	26·5%
1	43·5	27·2
2	49·2	28·6
3	57·4	34·0
4	65·0	41·8
5	71·8	49·8
6	78·2	57·2
7	83·0	65·8
8	87·5	73·4
9	91·2	80·1
10	93·4	84·4
11	95·8	88·4
12	97·0	90·4
13	97·8	92·4
14	98·4	94·1
15	98·8	95·5
16	99·2	96·6
17	99·4	97·6
18	99·6	98·0
19	99·8	98·8
20	100	99·7
21	100	99·8
22	100	100

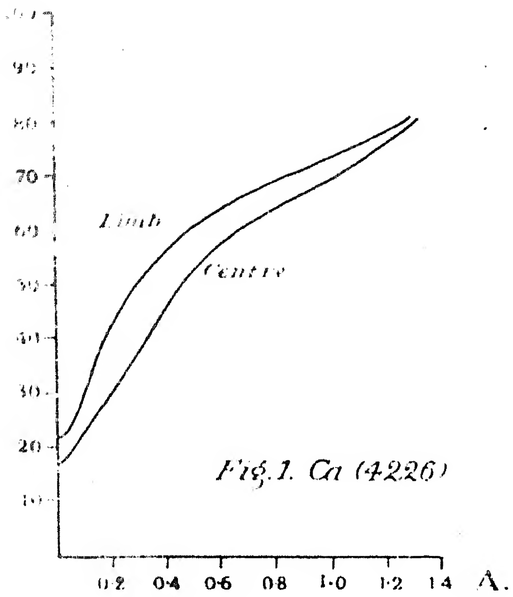

Fig. 1. Ca (4226)

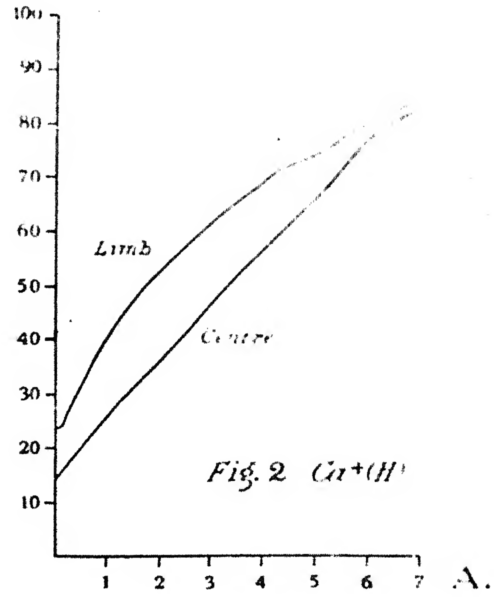

Fig. 2 Ca+(H)

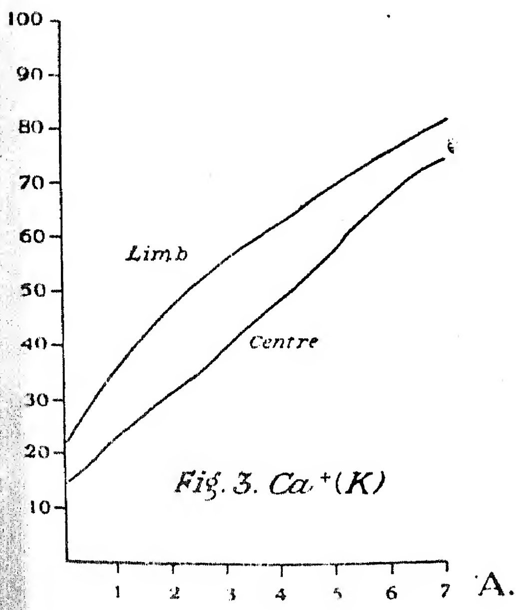

Fig. 3. Ca+(K)

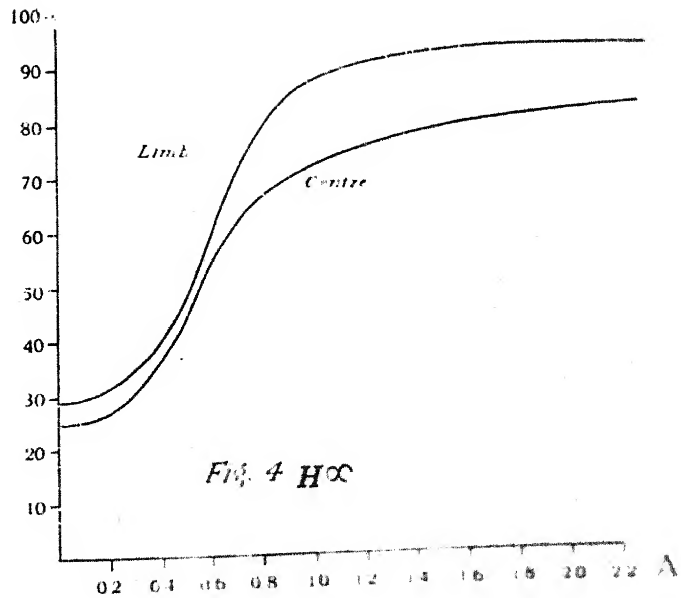

Fig. 4 Hα

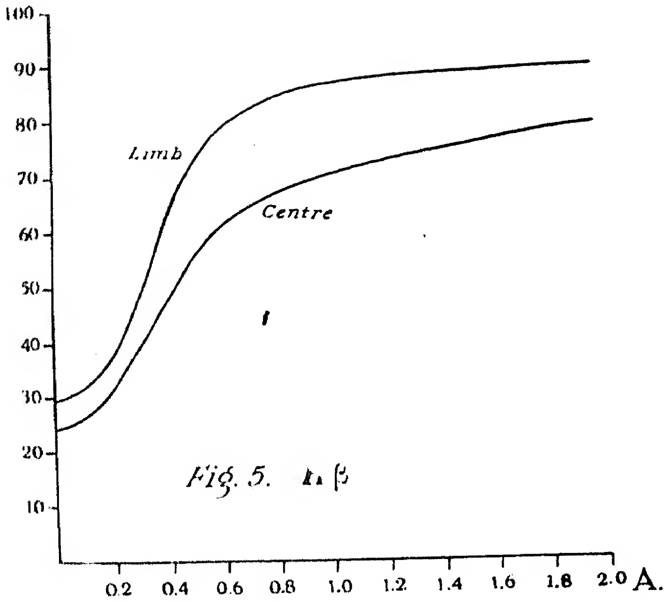

Fig. 5. H β

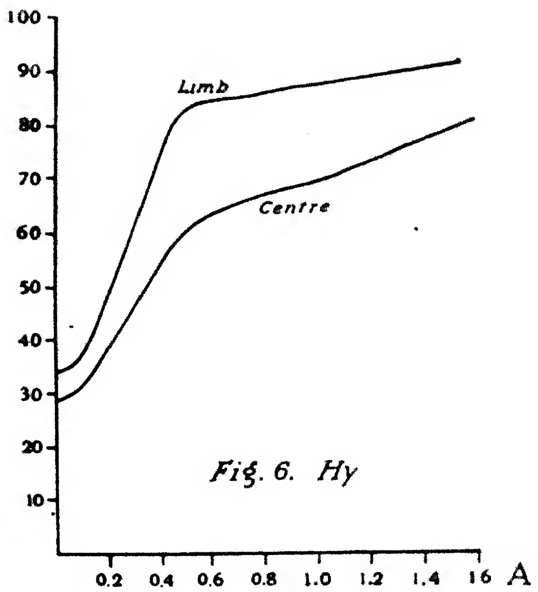

Fig. 6. Hγ

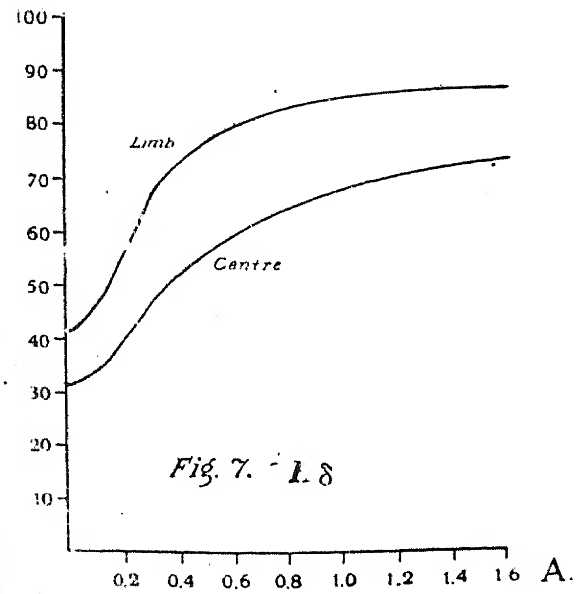

Fig. 7. H δ

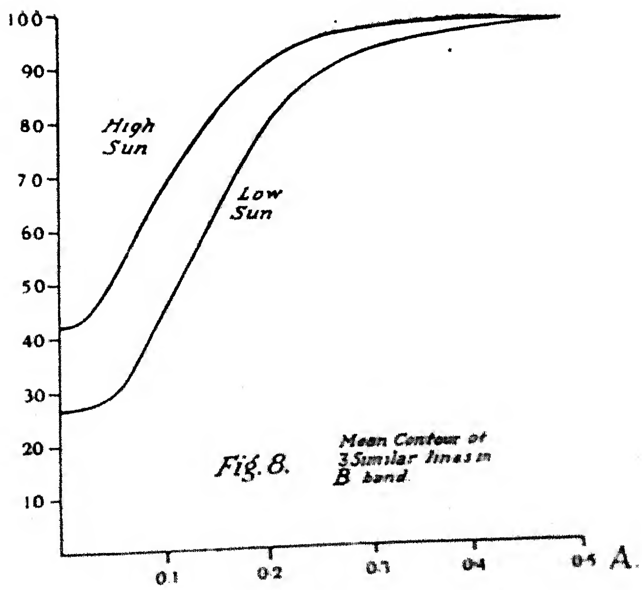

Fig. 8. Mean Contour of 3 Similar lines in B band

obtain photographs when the sky conditions were as nearly ideal as possible, the plates were of necessity taken at about the same time of the years 1934 and 1935, and the size of the sun's image was practically identical for all the plates taken. Consequently, the same holed plate in front of the slit as described on page [illegible] gave identical distances from the centre of the sun's disc for all the plates. The equivalent widths of the lines were obtained from the contour curves by determining the area of the space between the continuous spectrum and the contour curve over the whole width of the line. It should be noted that the value obtained for the equivalent width of these wide lines depends to a considerable extent on the point to which the extreme extent of the line is judged to stretch, and consequently that it is necessary to estimate the limits of the width of the lines as accurately as possible. This estimation is largely a matter of judgment, especially in those regions of the spectrum which are rich in lines, in which case it is often difficult to decide the limits of the absorption line. In some cases where the red or the violet wing is less confused by foreign lines than the other, it is useful to assume that the real extent cannot be very different on the two sides. The importance of the contribution of the wings to the total equivalent width may be judged from the results given in the tables IV to VII. Although the amount of absorption in the wings is small, the extent of the wings may be so great that the contribution to the equivalent width becomes considerable. Looking at table IV for the Hα line, the exact contours are given up to 100 units from the centre of the line, which is equivalent to 2·2 A. At this point the intensity of the line has risen to 85 per cent. of the intensity of the continuous spectrum. The exact contour of the line beyond this point is unimportant but it is important to fix the total width of the line. It was found to be sufficient to determine this total width of the line independently of the contour of the central portion of the line. The contour of the central portion of the line was determined from a large scale photometric record, *i.e.*, with the bromide paper on which the record is obtained moving at its maximum speed relative to the speed of the plate. As the exact contour in the wings is not important, the extreme width of the wings was estimated from records made with the minimum speed of recording so that a considerable length of the spectrum on each side of the line could be included in the record. Exact contours were thus obtained only for the central portions of the line, and approximate contours used for the wings, the limits of which were determined once for all for each position on the sun's disc from one photograph. No appreciable error in the equivalent widths can be introduced in this procedure. Reverting again to table IV for the Hα line, the equivalent width within 2·30 A from the centre of the line is 1·56 A but the equivalent width beyond this point amounts to 0·98 A. In the wings of the line it is not the exact shape of the contour which is important, but rather the great extent of the wing before the feeble absorption shades off into the continuous spectrum.

To derive the number of effective atoms in the sun's reversing layer from the equivalent widths in the above tables we adopt the method of Unsöld. Let us look first at the results for hydrogen. The f' values for the first 3 Balmer lines were calculated by Unsöld namely, 7·59 for Hα, 0·681 for Hβ and 0·191 for Hγ. Since the results for the higher members of the Balmer series will be neglected in the end, it is not worth while calculating the f' values for Hδ, but it has been taken as being of the order of 0·1.

Taking first the values for the centre of the sun's disc we see that as we ascend the Balmer series the values deduced for the number of effective absorbing atoms increase. This is because the conditions of pure scattering are seriously departed from in the sun, the cause being principally the Stark effect which is greater the higher we ascend in the Balmer series. The conditions of pure scattering are most nearly approached in the case of the Hα line, and we shall take the values for this line as the nearest approach we can get to the number of hydrogen atoms in the 2-quantum state. Using formula (4), we obtain for the upper limit to the number of hydrogen atoms in the 2-quantum state in the sun's reversing layer the value 12·0 × 10^{15} atoms per square cm. of the sun's surface. This value being an upper limit there seems to be no good reason for departing from

We now turn to the variation of equivalent width across the sun's disc. Although we are taking Unsöld's formula for deducing the number of atoms in the sun's reversing layer, the results for the variation across the disc do not really much depend on the particular formula used, but are rather dependent on the sole assumption that the equivalent width of a line is a measure of the total number of absorbing atoms. There is much more ground for the correctness of this assumption than there is for the assumption that absorption lines are formed by pure scattering. Whatever may be the conditions in the sun's reversing layer causing the Fraunhofer lines to be broadened beyond their so-called natural width, the chief effect of their variation in width across the sun's disc must be the variation in the number of absorbing atoms. Whatever role we give to other causes of broadening in the sun's reversing layer besides that of pure scattering, this role will be played to a similar extent at all parts of the sun's disc. Secondary effects may doubtless arise from these other causes of broadening as a result of the fact that near the limb of the sun the lines are formed at a higher effective level than at the centre of the sun's disc, but in a first examination of the problem we will neglect these effects. For the present, therefore, we will make no other assumption regarding the formation of absorption lines than that the equivalent width measures the number of absorbing atoms, using Unsöld's law of scattering merely for convenience, not vitally affecting the nature of the results obtained.

Coming back to the case of the B band of oxygen lines formed by absorption in the earth's atmosphere, we saw that when the path through the atmosphere is inclined to the vertical the effective width of the lines increases and the intensity at the centre of the line decreases, as the lines become broader and stronger. In the case of the sun's reversing layer the inclination of the path of the rays to the vertical becomes greater as we approach the sun's limb, and we might have expected an effect similar to the case of the B band had it not been well known that the observed effect is in the opposite direction. It has long been known that near the sun's limb the Fraunhofer lines become wider, that their wings on the contrary become weaker and the central absorption becomes weaker. This at once shows that the method of formation of the Fraunhofer lines in the sun's reversing layer is dissimilar to that of the terrestrial oxygen lines. A little consideration will show that the essential difference in the two cases is in the difference in the behaviour of the continuous background. In the case of the setting sun the background of continuous spectrum is the same as when the sun is overhead. This does not apply in the case of inclined and vertical rays from the photosphere through the sun's reversing layer. In this case the intensity of the background of continuous spectrum is weaker at the limb of the sun's disc than at the centre, the phenomenon being known as the darkening of the sun's limb. The cause of this phenomenon has been explained with universal acceptance as due to general absorption in the sun's reversing layer and to the temperature gradient in the sun. As the inclination of the rays of continuous spectrum increases towards the limb of the sun the intensity of the continuous spectrum emerging in the direction of the observer becomes weaker by general absorption. Expressed in other words, the effective level of general absorption is higher at the limb than at the centre of the disc, and as a result of the falling temperature gradient in the sun the emission from the higher level is weaker than that from the lower. Indeed the darkening of the sun's limb is the best evidence we have of a falling temperature gradient with height in the sun.

We may elaborate this point further. Looking at the sun's disc in the light of the continuous spectrum we look through the sun's atmosphere down to a depth sufficient to be opaque to light from below, and the continuous spectrum is of an intensity corresponding to the temperature of the average depth which is reached. At the sun's limb complete opacity is reached at a higher level than at the centre of the sun's disc on account of the longer path due to the greater inclination of the path to the vertical. If then this atmosphere should also show selective absorption in addition to the general absorption, we cannot possibly get the absorption [illegible] of atoms lying below the depth of complete opacity. In an absorption line therefore the atoms which are [illegible] forming the absorption line extend to less depths in the sun (measured vertically) at the limb [illegible] of the disc. On the other hand the greater inclination of the rays to the vertical when we are [illegible] [illegible] limb of the sun increases the effective number of atoms. As we proceed toward the sun's [illegible] forming [illegible]

limb we therefore have two opposing tendencies, (1) the smaller number of atoms above the higher level tending to diminish the width of the absorption line, and (2) the greater inclination of the path of light tending to increase the width of the line. We see from the tables I to VII that the former tendency slightly preponderates so as to make the equivalent widths at the limb actually less than at the centre of the disc. In the case of the Balmer lines, for example, we see that near the sun's limb the equivalent width is about one half of its value at the centre of the disc. For the H & K lines of Ca^+, the effect is smaller and we find very little change in the equivalent width until very close to the limb, for the apparent changes up to 0·86 radii from the centre have probably no real significance.

Returning now to the actual equivalent widths of the lines in different parts of the solar disc, we see from the tables I to VII that these widths gradually diminish towards the limb of the sun, the diminution being more rapid as the limb is approached. As we have stated previously, the equivalent widths found for the different points of the solar disc are taken to be measures of the number of absorbing atoms above the photosphere in the direction of observation. It follows therefore from what we have said above that we are measuring the effect not only of the number of atoms lying above the level of the photosphere, a level which is higher the nearer we approach to the limb, but also the effect of the increased length of path through the reversing layer as the inclination to the vertical of the direction of observation increases when we approach the limb of the sun. As we approach the limb we have first the effect of raising the photospheric level which is measured by the limb darkening in the continuous spectrum, and secondly, we have the effect of the inclination of the path through the reversing layer above this level. The increase of path due to its inclination to the vertical through the reversing layer is determined by geometrical considerations in the case of a homogenous atmosphere, namely proportional to the cosine of the angular distance of the point of observation from the centre of the sun's disc. For the actual reversing layer this is not strictly accurate but in view of the present unsatisfactory state of the theory of formation of absorption lines, a more accurate computation is not justified.

The change in contour of Fraunhofer lines as the limb is approached is apparently in different senses in different parts of the line. Hale and Adams[11] have shown that the absorption in the wings is less at the limb than at the centre of the disc, but that the core of the line is wider (apparently implying greater absorption). The actual contours as illustrated in figures 1 to 7 do however show that at the limb the absorption is less in all parts of the line and not in the wings alone. The apparent contradiction is due, to some extent (but not entirely), to physiological causes. The apparent effect of the core being widened at the limb is partly due to the physiological insensitiveness of the eye to the feeble absorption in the wings, causing the eye to misjudge the width of the core compared to the continuous background. Nevertheless the change in contour in different parts of the line as the limb is approached is not simple. The change in contour of a solar line as the limb is approached is markedly different from the change in the B band as the sun sinks lower in the sky. The exact interpretation of the more complicated behaviour of the solar lines is not clear, but it shows that the structure of the reversing layer is not so simple as that of the earth's atmosphere.

Our argument for the interpretation of our results may be stated, in effect, as follows. The equivalent width at the centre of the sun's disc measures the number of absorbing atoms above a certain level in the sun. The equivalent width at the limb measures the number of atoms above a higher level in the sun. Therefore, the difference between these two equivalent widths measures the number of atoms between the two levels, and if these levels are known we obtain immediately the density of the atoms between these levels. The varying inclination to the vertical of the path of light through the reversing layer is allowed for by geometrical considerations.

Before we can apply this argument we therefore have to translate the change of effective level of the photosphere as the limb is approached into actual depths in the sun. This is determined from the coefficient of general

[11] Hale and Adams, A. J., 25.300.1907.

absorption in the sun The effective level of the photosphere clearly depends on the level at which complete opacity is reached and thus in turn depends on the general absorption coefficient. Milne[12] from his expression for the general absorption coefficient namely $K=0\ 85\ P\left(\frac{T}{10^4}\right)^{\frac{9}{2}}$ has calculated the levels in the sun as a function of opacity His results have been modified by Chandrasekhar[13] who, by using a more probable value for the mean atomic weight of the constitutents of the sun s atmosphere obtains temperature gradients in the sun about 40 times smaller than those of Milne We shall here use the values given in Chandrasekhar s Table II

Milne s and Chandrasekhar s values for depths in the sun are expressed as a function of the optical depth in light of the continuous spectrum Milne has shown that Unsöld s procedure of measuring the distance from the centre of a line at which the residual intensity has risen to half of the background intensity corresponds to measuring the number of absorbing atoms above an optical depth of $\tau=\frac{1}{3}$ Instead of these so-called half widths we have used the equivalent widths We here adopt the same effective optical depth although our procedure differs slightly in that we have used equivalent widths in place of Unsöld s so-called half widths but the difference is not important for the results do not much depend on the actual optical depth chosen changing the adopted value for τ from $\frac{1}{3}$ to $\frac{1}{2}$ produces only a slight change in the results. We have therefore taken the effective optical depth of the photosphere at all points of the sun s disc as $\tau=\frac{1}{3}$ the path to this optical depth being inclined more and more to the vertical as we approach the limb of the sun. These inclined depths have been converted into vertical depths from geometrical considerations by multiplying by the cosine of the angular distance from the centre of the sun s disc. That is, we have taken the level of the photosphere to be at a vertical optical depth of $\tau=\frac{1}{3}\cos\theta$ The actual depths in the sun corresponding to the above vertical optical paths have been calculated from Chandrasekhar's equations in a manner similar to the values given in his table II Tables I to VII show that the changes in the equivalent widths of the lines studied are small and somewhat irregular until near the limb of the sun. It was therefore found sufficient to derive the results from three points only on the sun s disc at the following distances from the centre of the sun s disc measured in radii namely 0 0 86 and 0 98 The point at 0 86 radii gives results for a depth in the sun almost midway between the depths corresponding to the other two points For these three points the results derived from Tables I to VII are as follows —

TABLE IX —NUMBER OF ATOMS PER CM² ABOVE DIFFERENT HEIGHTS.

Sin θ	Cos θ	τ	T	h	Number of atoms per cm² above h. H (2-quantum)	Ca+	Ca
0	1 0	0 333	5348	0	12 0 $\times 10^{15}$	10 1 $\times 10^{16}$	3 10 $\times 10^{1}$
0 86	0 510	0 170	5113	136 km.	3 66	5 07	1 56
0 98	0 199	0 066	4948	287 km	0 63	1 22	0 50

From these results we calculate the density of atoms, i.e the number per cm³ in the reversing layer of the sun, as given in the following table In the last two rows of the table we have taken the whole reversing layer as extending to a height of 600 kms (as derived from eclipse results)[14] and that the number of atoms in

[12] Milne Phil Trans Roy Soc 228 421 1929

[13] Chandrasekhar M N R A S., 92.186.1932

[14] Handb d Ashophysik IV p 312

the chromosphere is negligible compared with the number in the reversing layer, the actual proportion for Ca+ being, according to Unsöld[15], less than $1 : 10^6$.

TABLE X.—NUMBER OF ATOMS PER CM³ IN REVERSING LAYER.

Heights above photosphere.	Number of atoms per cm³		
	Ca	Ca+	H (2-quantum).
0—136 kms.	$11\cdot3 \times 10^8$	$3\cdot68 \times 10^{11}$	$6\cdot13 \times 10^8$
0—287 kms.	$9\cdot05 \times 10^8$	$3\cdot40 \times 10^{11}$	$3\cdot61 \times 10^8$
136—287 kms.	$6\cdot95 \times 10^8$	$2\cdot55 \times 10^{11}$	$2\cdot01 \times 10^8$
0—600 kms.	$5\cdot2 \times 10^8$	$1\cdot7 \times 10^{11}$	$2\cdot0 \times 10^8$
287—600 kms.	$1\cdot6 \times 10^8$	$0\cdot4 \times 10^{11}$	$0\cdot2 \times 10^8$

It should be noted that the equivalent widths which we have found for the H and K lines of Ca+ are not exactly proportional to the square roots of their oscillatory strengths, as found by Unsöld for their half widths. Indeed, Unsöld, Struve and Elvey[16] have shown that the ratio of the equivalent widths of the H and K lines would be $\sqrt{2}$ for pure scattering, 2 for the case of Doppler broadening alone, and ~ 1 in the transition region, so that the ratio of their equivalent widths may be anything between 1 and 2. We actually find that the equivalent widths of the H and K lines are in the ratio $1\cdot2$, the ratio remaining practically constant across the whole disc. Consequently the number of atoms deduced for the two lines from formula (4) do not agree but are in the ratio $1\cdot2/1\cdot414 = 0\cdot85$. It is therefore sufficiently accurate for our present purpose to take the mean value for the two lines as the number of Ca+ atoms in the ground state.

It is well known that Saha's theory of ionisation enables the electron pressure to be calculated from the ratio of ionised to neutral atoms. The equation is[17], in the usual notation, where x is the fraction of the ionised atoms of any element,

$$\log \frac{x}{1-x} = -\frac{5040\,\mathrm{I}}{\mathrm{T}} + \tfrac{3}{2} \log \mathrm{T} - 6\cdot49 - \log \mathrm{P}_e + \tfrac{1}{2} \log \frac{\mathrm{T}_1}{\mathrm{T}} + \log \tfrac{1}{2} + \log \frac{\sigma \mathrm{B}'}{\mathrm{B}}.$$

It seems clear that for T, the effective temperature, we should for our purpose take the effective temperature of the radiation from the centre of the sun's disc, and not from the disc as a whole. This temperature we have taken as 6070°, and for T_1 we have taken, from Chandrasekhar's tables, the mean temperature between the levels considered. For calcium, $\mathrm{I} = 6\cdot09$, $\frac{\sigma \mathrm{B}'}{\mathrm{B}} = 2$ and we have from the results in Table X, the following values for the ratio of ionised to neutral calcium atoms, giving the accompanying values of the electron pressure :—

TABLE XI.—IONISATION OF CALCIUM IN THE REVERSING LAYER.

Heights above photosphere.	0—136 kms.	136—287 kms.	0—287 kms.	Whole reversing layer.
$x/(1-x)$	$3\cdot29 \times 10^2$	$3\cdot63 \times 10^2$	$3\cdot40 \times 10^2$	$3\cdot25 \times 10^2$
Electron pressure in atmospheres	$2\cdot4 \times 10^{-5}$	$1\cdot7 \times 10^{-5}$	$1\cdot9 \times 10^{-5}$	$2\cdot1 \times 10^{-5}$

15 Unsöld, Ap. J., 69, 297, 1929.

At these electron pressures the number of doubly ionised calcium atoms should be taken into account in obtaining the total number of calcium atoms We have the following results for the average number of calcium atoms per c c at different levels

TABLE XII —NUMBER OF NEUTRAL AND IONISED ATOMS ~~AND~~ of CALCIUM PER C. C. IN REVERSING LAYER.

Heights above photosphere		0—136 kms.	136—287 kms.	0—287 kms.
Number of atoms per cm³	Ca	$0{\cdot}01 \times 10^{11}$	$0{\cdot}01 \times 10^{11}$	$0{\cdot}01 \times 10^{11}$
	Ca.+	3·68	2·55	3·40
	Ca.++	0·07	0·06	0·08
Total number of calcium atoms per cm³		$3{\cdot}76 \times 10^{11}$	$2{\cdot}62 \times 10^{11}$	$3{\cdot}49 \times 10^{11}$
Partial pressure due to calcium atoms		$2{\cdot}69 \times 10^{-1}$ dynes/cm²	$1{\cdot}80 \times 10^{-1}$ dynes/cm²	$2{\cdot}46 \times 10^{-1}$ dynes/cm²

Having determined the number of atoms per c. c. of any particular element which constitutes a known fraction of the total number of atoms present in the sun, we can next determine the density of all atoms and total gas pressure Our results for hydrogen cannot be used for this purpose on account of the great uncertainty of the ratio of the number of atoms in the ground state in the sun to the number in the 2 quantum state and it is the latter alone that we are in a position to determine. Indeed the proportion of the non-metallic elements in the sun relative to the metallic elements is a matter of great uncertainty due, principally, to the fact that the lines of the non-metals which determine the number of atoms in the ground state are not observable Nevertheless, Russell[18] has made estimates of the relative proportion of all the elements in the sun, and we take his value of the proportion of Ca to make use of our results to derive the total number of atoms of all kinds in the reversing layer. According to Russell, the number of calcium atoms in the sun's reversing layer is about 0 064 per cent. of the total number of atoms present. Our results have given the number of atoms per c. c. at different levels in the reversing layer and assuming the same proportion of calcium atoms at all heights, we deduced the following values for the total gas pressure in the reversing layer.

TABLE XIII.—TOTAL GAS PRESSURE IN THE REVERSING LAYER IN DYNES PER CM²

Height above photosphere.	0—136 kms.	136—287 kms.	0—287 kms.
Partial pressure of Ca (dynes cm²)	$2\ 69 \times 10^{-1}$	$1\ 80 \times 10^{-1}$	$2\ 46 \times 10^{-1}$
Total gas pressure (dynes cm²)	$4{\cdot}2 \times 10^{2}$	$2\ 8 \times 10^{2}$	$3{\cdot}8 \times 10^{2}$

These values for the total gas pressure depend on the assumed proportion of calcium atoms in the reversing layer They are higher than Chandrasekhar's values [19] of the gas pressure deduced from Milne s theory

Taking Chandrasekhar's values for the gas pressure at the levels considered and our values of the partial pressure of the calcium atoms, we deduce that the proportion of calcium at all the levels considered of the reversing layer is 0 6 per cent of the total number of atoms present about 10 times the estimate of Russell.

We acknowledge our indebtedness to the Nizamiah Observatory for the loan of the 15 object glass used to form an image of the sun for this research and to Mr C P S. Menon, M.A. who assisted in the early stage of the work which he had to leave on taking up an appointment

[1] Russell A J 70 11 1929 and A J 75 337 1932

KODAIKANAL OBSERVATORY

25th November 1936

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Kodaikanal Observatory.

BULLETIN No. CX.

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE SECOND HALF OF THE YEAR 1935.

In pursuance of the programme of work adopted since 1st January 1923 under the auspices of the International Astronomical Union, all observatories taking spectroheliograms of the sun have been asked to co-operate with the Kodaikanal Observatory by supplying copies of their photographs for those days when the Kodaikanal records are imperfect or wanting. In response to our requirements for the second-half of the year 1935, the Mount Wilson Observatory supplied calcium (K_{232}) prominence plates for 54 days and H α disc plates for 43 days, the Meudon Observatory supplied calcium (K_3) disc plates for 8 days and H α disc plates for 36 days and the Ewhurst Observatory (Mr. J. Evershed's) supplied H α prominence plates for 4 days and H α disc plates for 6 days.

When only incomplete or imperfect photographs for any day are available from more than one observatory the best photograph is chosen as representing the solar activity of that day, after weighing it according to its quality, and the remaining photographs are ignored.

Calcium Prominences at the Limb.—The mean daily areas and numbers of prominences photographed during the half-year by means of the K line of calcium are given below. The means are corrected for incomplete or imperfect observations, the total of 173 days for which plates were available being reduced to 145 effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North	2·65	6·72
South	2·70	6·85
Total	5·35	13·57

Compared with the previous half-year, areas show an increase of 19 per cent, numbers remaining almost the same. The increase in areas is considerably more in the northern hemisphere than in the southern.

For comparison with bulletins issued prior to the co-operation of other observatories the means based on Kodaikanal photographs alone are also given, 125 days of observation being counted as 109½ effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North (Kodaikanal photographs only)	2·54	6·65
South (do.)	2·61	6·58
Total	5·15	13·23

The distribution of prominences in latitude is represented in the following diagram, in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude. The ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line. Compared with the previous half-year, the distribution remains unchanged in the northern hemisphere, whereas in the

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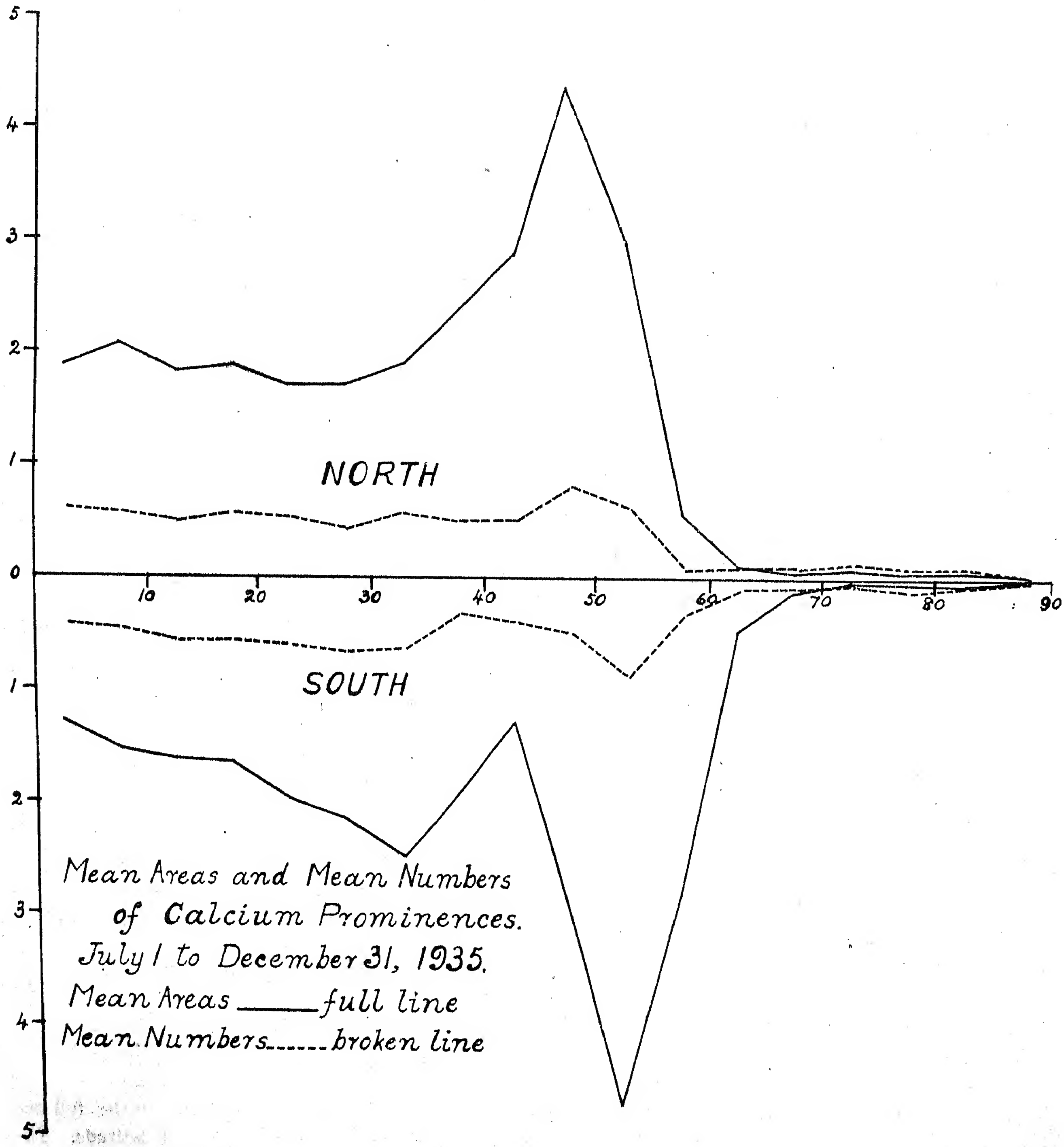
southern hemisphere the zone of maximum activity has advanced 5° towards the pole and there is reduced activity in the zones 10°-15° and 40°-45°.



The monthly, quarterly and half-yearly areas and numbers and the mean height and the mean extent of the prominences on photographs from all co-operating observatories are given in Table I. The unit of area is 1 square minute of arc. The mean height is derived by adding together the greatest heights reached by individual

prominences and dividing by the total number of prominences observed, and the mean extent is derived by adding together the lengths of the base on the chromosphere of individual prominences and dividing by the total number of prominences.

TABLE I.—ABSTRACT FOR THE SECOND HALF OF 1935.

Months.	Number of days (effective).	Areas.	Numbers.	Daily means.		Mean height.	Mean extent.
				Areas.	Numbers.		
1935.						″	°
July	$23\frac{1}{2}$	108·8	294	4·6	12·5	39·8	5·65
August	24	117·5	321	4·9	13·4	38·3	5·79
September . . .	27	166·5	353	6·2	13·1	40·3	6·08
October	$24\frac{1}{2}$	101·5	372	4·1	15·2	38·7	4·76
November . . .	$22\frac{1}{2}$	137·7	322	6·1	14·3	38·0	6·12
December . . .	$23\frac{1}{2}$	142·8	301	6·1	12·8	41·7	7·39
Third quarter . . .	$74\frac{1}{2}$	392·8	968	5·3	13·0	39·5	5·85
Fourth quarter . . .	$70\frac{1}{2}$	382·0	995	5·4	14·1	39·4	6·00
Second half-year .	145	774·8	1,963	5·3	13·5	39·5	5·93

Distribution East and West of the Sun's Axis.

Both areas and numbers show a defect at the east limb, that in areas being more marked, as will be seen from the following table :—

1936 July to December.	East.	West.	Percentage East
Total number observed	970	993	**49·41**
Total areas in square minutes	352·1	422·6	**45·45**

Metallic Prominences.

Thirteen metallic prominences were observed during the half-year and their details are given below :—

TABLE II.—LIST OF METALLIC PROMINENCES. JULY TO DECEMBER 1935.

Date.		Time I. S. T.		Base.	Latitude. North.	Latitude. South.	Limb.	Height.	Lines. (See note at end of table).
		H.	M.	°	°	°		"	
1935.									
July						*Nil*			
August	30	9	45	3	..	33	W	15	4 and 10.
September	27	9	17	3	25·5	..	W	20	4 and 10.
October	22	9	27	2	..	19	W	10	4 and 10.
November	3	9	05	2	..	32	E	10	4 and 10.
	29	9	08	5	..	19·5	W	15	4 and 10.
December	4	10	53	1	..	24·5	E	15	1, 3, 4, 5, 7, 8, 10 and 12.
	8	10	22	5	..	27·5	W	20	1, 3, 4, 5, 9, 10, 11 and 12.
	9	9	35	4	..	28	W	25	1, 3, 4, 5, 9, 10, 11 and 12.
	10	8	38	..	..	27	W	20	1, 2, 3, 4, 5, 7, 9 and 10.
	11	10	43	..	..	28	W	15	1, 2, 3, 4, 5, 7, 8, 9, 10, 11 and 12.
		10	45	1	..	25·5	W	10	1, 2, 3, 4, 5, 7, 8, 9, 10, 11 and 12.
	23	10	18	3	..	22·5	E	20	1, 2, 4, 9, 10, 11 and 12.
	30	10	40	3	..	30·5	E	10	4, 8, 10, 11 and 12.

NOTE.—The key to the wave-lengths of metallic lines is as follows :—

No.	λ	Element.	No.	λ	Element.
1	4924·1	Fe+	7	5276·2	Fe+
2	5016·0	He	8	5316·8	Fe+
3	5018·6	Fe	9	5363·0	Fe+
4	b_4, b_3, b_2, b_1	Mg. Fe+	10	D_2, D_1	Na
5	5234·8	Fe	11	6677	He
6	5276·0	Cr	12	7065	He

The distribution of metallic prominences was as follows :—

	1°—10°.	11°—20°.	21°—30°.	31°—40°.	Mean latitude.	Extreme latitudes.
North	..	..	1	..	25°·5	25°·5
South	..	2	8	2	26°·4	19°·0 and 33°·0

Four were on the east limb and nine on the west limb.

Displacements of the Hydrogen Line.

Particulars of displacements observed in the chromosphere and prominences with the spectroscope are given in the following table :—

TABLE III.—DISPLACEMENTS OF THE HYDROGEN LINE. JULY TO DECEMBER 1935.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
		H.	M.	°	°		A.	A.	A.	
1935.										
July	18	10	40		40	W	1·5			At top; extends over 4° from —38° to—42°.
	20	10	52		20	W	1			At top.
	23	9	23		39·5	E	Slight			At base; extends over 3° from —38° to —41°.
August	3	11	59		22	W		Slight		At top.
	23	8	35	2		W			Slight	In chromosphere.
	28	9	35	16		W		Slight		Do.
	30	10	10		35	W	Slight			At base.
		9	45		33	W	0·5	0·5		To red at top and to violet at base; extends over 3° from —31·5° to —34·5°.
September	13	9	15	28·5		E		0·5		At top; extends over 3° from +27° to +30°.
		9	2		18	W		Slight		At base.
		9	2		16	W	Slight			At top.
	19	9	00	61		E	Slight			In chromosphere.
		9	5	27·5		E		1·5		At top; extends over 3° from +26° to +29°.
		9	24		57·5	E	1·5			At top; extends over 4° from —55·5° to —59·5°.
	20	9	32	36·5		W		Slight		In chromosphere.
	21	9	53	68		E		1		At top.
	22	9	15	34·5		E		0·5		At top; extends over 2° from +33·5° to +35·5°.
		9	4	12		W	2			At top; extends over 2° from +11° to +13°.
		9	2	31·5		W	1·5			At base.
	23	9	15	32·5		E		1		At top of floating prominence; extends over 2° from +31·5° to +33·5°.
		9	21		44·5	E	0·5			At base.
		9	3	26·5		W	1			At top; extends over 5° from +24° to +29°.
	24	9	27		7·5	E		Slight		At top.
		9	15	8		W	Slight			Do.
		9	8	22·5		W		1·5		At base.
	26	9	20	65		E	1			Do.
		9	05	21·5		W	0·5			At middle of prominence; extends over 3° from +20° to +23°.
		9	00	69		W	Slight			In chromosphere.
	28	8	58		33·5	E	Slight			At top.
		9	27	61		W		0·5		Do.

Date.		Hour I.S.T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
		H.	M.	°	°		A.	A.	A.	
1935.										
October	3	9	45		19·5	E	Slight			At base.
		9	33		55	W	2			At top; extends over 3° from —53·5° to 56—5°.
	6	9	18	72		E	0·5			In chromosphere.
	21	9	25		15·5	W		1		At base.
	22	9	27		19	W	Slight			At top.
	26	9	38		30	E		Slight		Do.
		10	00	19		W	2			Over the whole detached prominence.
November	1	10	29		23	E	Slight			At base.
	3	8	58		30	E		1		At top.
		8	58		31	E	1			At base.
		8	55		33	E	1			At top.
	5	8	35	80		E	0·5			Do.
	6	10	34	31		E		Slight		Do.
		10	32	23		E		Slight		Do.
	8	9	00		16	W	Slight			At top; extends over 2° from —15° to —17°.
	9	9	42	21		E		1		At top.
		10	12	57		W	Slight			Do.
	19	9	40		27	E		Slight		At top; extends over 2° from —26° to —28°.
		9	30		51	W		0·5		At base; extends over 2° from —50° to —52°.
		9	23		30·5	W		2		At base; extends over 3° from —29° to —32°.
	27	9	38		30	W	Slight			At top.
		9	41		17·5	W		1		Over the whole prominence.
		9	46		15	W		1		At base.
	28	9	11		16	W		0·5		At top.
		9	11		12	W			0·5	Do.
	29	9	29		30·5	E	Slight			At base.
	30	11	03	68		W		1		In chromosphere.
		11	05	83		W	1			At top.
December	2	9	22		12·5	W		2·5		At base.
		9	17	68·5		W		1		At top.
	3	8	24	7		W	Slight			In the middle of prominence.
	4	11	19		23	E		1		At top.
	6	9	38	86		E		Slight		At base.
	8	10	39	23		E	1			Do.
		10	32		69	W		Slight		In chromosphere.
		10	23		38	W		0·5		At top.
		10	20		25	W	1			Do.
	9	11	05		83	E	1			Do.
		9	48		32	W	1·5			At top; extends over 2° from —31° to —33°.
		9	35		28	W		0·5		At base.
		8	38		27	W	4	2		To red at top and to violet at base.
		9	35		26	W	1			At top; extends over 2° from —25° to —27°.
		9	35		20	W	1			At top; extends over 4° from —18° to —22°.
		8	30	85		W	Slight			In chromosphere.
	11	10	43		28	W	1			At top.
		11	9	50		W	1·5			Do.
	14	10	26	13		E			1	At base; extends over 2° from —12° to —14°.
	23	10	12		12·5	E		1		At top; extends over 7° from —9° to —16°.
	30	10	21		30·5	E	2			At base; extends over 3° from —29° to —32°.
		10	40		30	E		2		At base.
		10	43		32·5	E		1·5		At top.

The total number of displacements was 83 as against 91 in the previous half-year and their distribution was as follows :—

	North.	South.
1°—30°	15	29
31°—60°	7	18
61°—90°	12	2
Total	34	49

East limb	34
West limb	49
Total	83

Of these displacements, 43 were towards the red, 37 towards the violet and 3 both ways simultaneously.

Reversals and displacements on the Sun's disc.

One hundred and ninety six bright reversals of the Hα line, 164 dark reversals of the D_3 line and 14 displacements of the Hα line were observed with the spectroscope during the half-year. Their distribution is given below :—

	North.	South.	East.	West.
Bright reversals of Hα	87	109	91	105
Dark reversals of D_3	70	94	75	89
Displacements of Hα	3	11	8	6

Seven displacements were towards the red, two towards the violet and five both ways simultaneously.

The Hale spectrohelioscope has been used daily (except on Sundays and holidays) for the observation in the light of the Hα line of changing phenomena and of displacements which cannot readily be photographed. The hours allotted by the International Astronomical Union to this observatory for spectrohelioscope observations are 2-30 to 3-00, 4-00 to 4-30, 5-30 to 6-00 and 6-30 to 7-00 G. M. T. or 8-00 to 8-30, 9-30 to 10-00, 11-00 to 11-30 and 12-00 to 12-30 I. S. T. but observations are continued at other times in cases where interesting developments are likely to occur. A summary of the observations made during 1935 are given below.

			East limb.	West limb.	Total.
Displacements in prominences			20	23	43
	North.	South.	East.	West.	Total.
Displacements in Hα dark markings	42	89	59	72	131
Displacements in Hα bright flocculi	6	8	8	6	14

	Displacements towards Red.	Violet.	Both ways.	Total.
Prominences	25	17	1	43
Hα dark markings	78	53	..	131
Hα bright flocculi	8	6	..	14

Prominences projected on the Disc as Absorption Markings.

Photographs of the sun's disc in Hα light were available from Kodaikanal and the co-operating observatories for a total of 175 days which were counted as 160 effective days. The mean daily areas of Hα absorption markings (corrected for foreshortening) in millionths of the sun's visible hemisphere and their mean daily numbers are given below :—

	Mean daily areas.	Mean daily numbers.
North	2079	12·76
South	3415	14·97
Total	5494	27·73

The above show an increase of 58 per cent in areas (the increase in the northern hemisphere being 117 per cent), and 43 per cent in numbers, compared with the previous half-year.

For comparison with bulletins issued prior to the co-operation of other observatories the means based on Kodaikanal photographs alone are also given, 102 days of observation being reduced to 94 effective days :—

	Mean daily areas.	Mean daily numbers.
North (Kodaikanal Photographs only)	2383	13·80
South (do.)	3551	15·83
Total	5934	29·63

Kodaikanal Observatory

BULLETIN No CXI

A PROGRESSIVE CHANGE IN THE INCLINATION OF HYDROGEN DARK MARKINGS TO THE MERIDIAN OF THE SUN

BY

T ROYDS AND M SALARUDDIN

SUMMARY

The nclinat on of hydrogen dark m l ng to the s la m dan has been measur d at eacl ucc s ve otat n of the fo wh h the ma k ng nay e dure The study mprises all su table dark markings in th years 1923—1933 e f a onplet 11 year y le a recorded in tl e Meudon cha t It s found that th polar end f a da k ma king drifts m d no e a te ly of tl e equatorial end t a h su cess e otat n f the sun the average hange f n lınat on of a da k mark g n e otat on of tl e un am unt g t 0 47 f r tl change in the c tang nt of the angle whi h the dark ma king m kes w th a par ll l of latitude

The nly ad t explanat on fo tl p ogress e change f lınat on is that it s duc to the polar reta d t n f tl te f th s rotat n The an unt t be expected f om this theory is 0 51 a ó pa d w th the abo e alu of 0 47 l h e g l l a b g n t sfa t ry agreeme t

Sin tl g og l a g s rega ded as be ng ad quately explain d by the p la retardat on t se ms p ob bl that th icl nat o t l (w th the polar end n ore a d more to tl e t t i increase of lat tude in the sun a f l Kod kanal Ob at ry B ll t n N 63) are also l e to the pola retardation In this case w are dri n to a ume th t e pe ally n l ghe l t t les the solar d turbance n wh ch the hydrogen marking originates has already been in exis te e s m cons de abl t n e l fo tl e dark ma king appears on the surface of the sun the only alternat e to this hypo th seems to be tl at tl s so onst t te l that the f rmat on f dark markings in direction othe than those pref rred (a l ng t ol t) l ff ult

In Kodaikanal Observatory Bulletin No 63[1] it was shown that hydrogen dark markings do not lie arbitrarily oriented on the surface of the sun but have a tendency to lie with their polar ends to the east of their equatorial ends Their mean inclination towards the east varies with latitude It was suggested that the easterly drift of the polar end of dark markings was caused by the polar retardation of the sun s rotation which makes the more slowly rotating higher latitude drift to the east of the lower latitude If the polar retardation of the sun s rotation is the sole cause of the inclination of hydrogen dark markings to the east it follows that the age of the dark marking must be sufficiently long for the observed inclination to the east to develop and it was pointed out in the bulletin referred to that the time required for the dark markings to develop the observed inclination in the higher latitudes was much greater than the observed ages of the markings

It is the purpose of the present bulletin to investigate another possible effect of polar retardation on dark markings If the polar retardation of the sun s rotation is the cause of the easterly inclinations of dark markings it is to be expected that at each successive rotation of the sun the easterly inclination of any dark marking which persists should increase by an appreciable amount An example of this is illustrated in Kodaikanal Observatory Bulletin No 89[2] figures 2 and 3 which show the change in inclination of a dark marking after one complete rotation of the sun namely from 40 between the meridian and the marking to 55

In order to study a reasonable number of markings a period extending over a complete 11 year solar cycle has been taken The study of so long a period has become amenable through the facilities afforded by the charts

( ) Royds K daikanal Observatory Bulletin No 63 p 289
( ) Royds Kodaikanal Observatory Bulletin No 89

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of dark markings published by the Meudon Observatory, Paris,[1] with the assistance of grants from the International Astronomical Union. On these charts, the dark markings are presented for each rotation of the sun, so that it becomes a practicable proposition to study from them the inclinations of persistent markings at each successive rotation of the sun for a long period. The method adopted has been to lay a transparent protractor over the charts and to read off the inclinations of those dark markings which last for a complete rotation or more. A separate measure was made for each zone of 10° of latitude over which a dark marking might stretch. The method of representation of the sun in Mercator's projection in the Meudon charts does not affect the inclinations to the sun which are measured in this way. Those markings with inclinations to the meridian[2] greater than 70° have been neglected because the tangent of the inclinations, which (as will be seen later) is the factor to be studied, then increases so rapidly that any inaccuracy in the measurement of the inclinations (or rather small irregularities in the inclinations) becomes of considerable effect. This elimination has also had the effect of confining the latitudes studied to those between $\pm 40°$, for the dark markings in higher latitudes are almost invariably nearly parallel to the equator.

In this way, we have measured the inclinations of all suitable dark markings in the years from 1923 to 1933 inclusive. All markings lasting for one rotation or more have, as far as possible, been measured, but some markings are too irregular in shape to have a definite direction assigned to them. In all, 66 dark markings have been measured, yielding 257 values of the change of inclination after one complete rotation of the sun. A progressively greater inclination with each rotation of the sun is clearly seen in the majority of markings (see, for example, the marking illustrated in Kodaikanal Observatory Bulletin No. 89 already referred to) but naturally there are many irregularities in different markings. Occasionally it happens that the inclination of a marking may, at a certain rotation, have made a sudden jump (backwards or forwards) compared with the normal tendency. Such jumps have been neglected whenever the life of the dark marking has been interrupted between the successive rotations as recorded on the Meudon charts. Naturally interruptions may, without our knowledge have occurred whilst on the side of sun turned away from the earth. Such possibilities cannot be taken into account.

In a study of this character where the quantity to be measured is subject to many irregularities, if not exceptions to the general rule, it is desirable to avoid, as far as possible, prejudices due to preconceived ideas of what general behaviour should be expected. In order to avoid any such biassed judgment all measurements of inclinations were made and completed before considering whether they were in accordance with the effect of the solar rotation on the variation of the inclination of markings with each successive rotation. But for a logical presentation of the treatment of the data which has been adopted in this bulletin, it is necessary to discuss first the effect of solar rotation. According to d'Azambuja[3] the speed of rotation of hydrogen dark markings varies with latitude according to the following law:

$$\xi = 14°{\cdot}44 - 1°{\cdot}60 \sin^2 \varnothing$$

where ξ is the angular rotation per siderial day. The change of inclination to be expected from the polar retardation of rotation is therefore given by $\frac{d\xi}{d\varnothing} = \cot\theta' - \cot\theta$, as seen in fig. 1, θ and θ' being the inclinations of the dark markings to a parallel of latitude (complement of the inclination to the meridian) for successive days. For a difference of one solar rotation as represented on the Meudon charts, the change in inclination due to polar retardation will be

$$\text{Cot}\,\theta' - \cot\theta = 1{\cdot}523 \sin\varnothing \cos\varnothing.$$

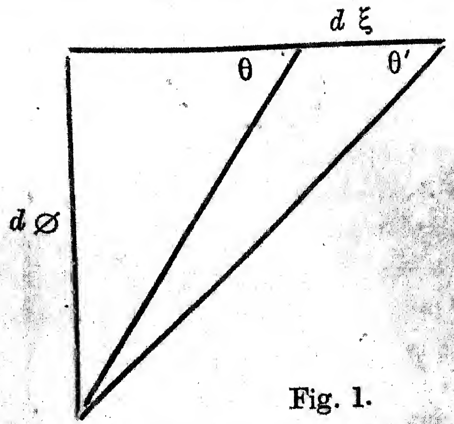

Fig. 1.

(1) d'Azambuja, Cartes synoptiques.

(2) Footnote. For brevity, the expression "inclination to the meridian" is often used whereas there are many conveniences in using the complement of this angle, namely the inclination to a parallel of latitude. When the former convention is used it is the tangent of the inclination which is to be studied and when the latter convention the cotangent of the inclination.

(3) d'Azambuja, Cartes synoptiques, Vol. I, Fasc. 1. 1934.

Consequently we see that to correlate the progressive change in the inclination of the markings with the effect of polar retardation we have to study the change in the cotangent of the inclination of the marking An example is given below —

TABLE I —EXAMPLE OF MARKING No 3246 *et seq* LATITUDE 20 —30°N

Rotation No	966		967		968		969		970		971
Inclination	60		50		47		42°		32°		26°
Cot θ	577		839		932		1 111		1 600		2 050
Change in Cot θ		262		093		179		489		450	

The mean value of the change in cotθ for this marking is 0 295 but the mean for all markings in latitude 20 —30 is 0 508 as seen in table II and the value to be expected from d Azambuja s law of solar rotation for latitude 25 is 0 583

A summary of all our results is given below in Table II

TABLE II —AVERAGE CHANGE IN THE COTANGENT OF THE ANGLE OF INCLINATION TO A PARALLEL OF LATITUDE FOR ONE SOLAR ROTATION

Latitude	0 —10	10 —20°	20 —30°	30°—40°
Average change in Cot θ	0 424	0 364	0 508	0 591
No of markings	3	79	108	47
Average change for all latitudes 0 —40	0 471			

The average change of cot θ for one rotation of the sun for all markings studied between latitudes 0 and 40 in the years 1923 to 1933 is 0 471 Their mean latitude is about 22½ and the polar retardation of rotation would give for this latitude the value 0 539 which is in agreement as close as one would expect The solar retardation would give the value 0 471 in agreement with observation, for latitude 19

We are therefore led to the conclusion that the effect of polar retardation of rotation is a sufficiently complete explanation of the progressive change in the inclination of dark markings to the solar meridian. This conclusion strengthens the supposition that not only is the change of inclination with time due to the polar retardation but also the inclinations themselves as found on the sun are attributable to the same cause If dark markings were oriented with equal frequency in all directions the average inclination to a parallel of latitude in the procedure adopted in this and in previous bulletins referred to would be 90 for the northern and southern hemispheres taken separately It was found in Kodaikanal Observatory Bulletin No 63 that the average inclination of dark markings in the period January—June 1913 was in all latitudes, with their polar end to the east of their equatorial end the amount varying with latitude To obtain more accurate values a longer period has now been taken namely 1928 to 1930 and the inclinations have been read off by protractor more accurately than the approximate procedure adopted in Kodaikanal Observatory Bulletin No 63 The following average values have been obtained

TABLE III.—AVERAGE INCLINATION OF DARK MARKINGS (POLAR END IS EAST OF THE EQUATORIAL END).

Latitude.	0°—5°	5°—10°	10°—15°	15°—20°	20°—25°	25°—30°	30°—35°	35°—40°	40°—45°	45°—50°	50°—55°	55°—60°
Inclination to parallel of latitude.	86°	79°	73°	62°	46°	45°	32°	29°	17°	20°	23°	17°
Inclination to meridian (complement of above angle).	4°	11°	17°	28°	44°	45°	58°	61°	73°	70°	67°	73°

These values are consistent with those found in the previous bulletin, taking into account the less accurate procedure there adopted which has the greatest effect in high latitudes. It was then pointed out that if these inclinations were caused by the polar retardation, a supposition which is strengthened by the progressive change found in the present bulletin, it necessitated a certain age of the markings in order to allow the observed inclination sufficient time to develop, and it was shown that the ages so deduced[1] increased with latitude more rapidly than the actual durations of dark markings (although it is difficult, from the nature of the case, to determine the duration of markings with any accuracy). Now it is to be noted that, at any rate in the higher latitudes, the markings already present an eastward position of their polar ends when the markings first appear. Indeed in the high latitudes, they almost invariably lie along a parallel of latitude at their first appearance and do not gradually develop into this orientation. If their inclinations are due to the polar retardation, a view which is strengthened by the evidence in this bulletin, it follows that the retardation must have been operating (at least for high latitudes) before the dark marking appears at the surface of the sun, *i.e.*, the marking is already old when it first appears at the solar surface, and the origin of the dark marking must have been in existence some considerable time before its appearance at the surface with a large inclination to the meridian of the sun. It is therefore to be supposed that the solar disturbance in which the dark marking originates is operating below the surface of the sun before the marking comes up to the surface for a period which is greater in higher latitudes. There is one alternative to this supposition, namely, that the sun is so constituted that dark markings, instead of being originally distributed arbitrarily in any direction, are difficult of formation except in the preferred direction in which they are observed to lie on the surface of the sun at their first appearance.

We must not fail to mention two considerations which are, at first sight, unfavourable to the view that the progressive change of inclination is solely due to the polar retardation of the sun's rotation. The progressive change might have been investigated by comparing the average inclination of all markings at their first appearance on the sun with all markings at each successive appearance. If this is done, the evidence is not quite clearly favourable to the hypothesis. As will be seen from the following table there is a progressive change only for the first few rotations and no regular change thereafter.

TABLE IV.—INCLINATION OF ALL DARK MARKINGS CLASSIFIED AS ENDURING MORE THAN ONE ROTATION.

Rotation.	1st	2nd	3rd	4th	5th	6th	7th	8th	9th
Inclination to parallel of latitude . .	64°	52°	51°	41°	44½°	49°	39°	50°	51°

(1) Kodaikanal Observatory Bulletion No. 63. The ages were deduced taking the polar retardation in the reversing layer. If d'Azambuja's rate of polar retardation for dark markings is taken, the ages deduced are still greater.

Apparently the reason for the failure of the inclination to decrease after a few rotations is that when all markings are considered the number of new births in the same longitude as a previous marking overbalances (specially as the order of rotation increases) the effect which is found by considering only individual dark markings that have undoubtedly continued uninterrupted And secondly we have the fact seen from Table V that although the average change is sufficiently near the value expected from the rate of polar retardation of the sun's rotation the variation with latitude is not so near the expected variation This is evident in the following table V

TABLE V —VARIATION OF PROGRESSIVE CHANGE WITH LATITUDE

Mean latitude	5	15	25°	35
Average change (from Table II)	0·424	0·364	0·508	0·591
Change according to law of polar retardation	0·132	0·381	0·583	0·715

Naturally the expected variation depends on the law of solar rotation adopted It is not a very simple matter to determine the law of rotation of dark markings partly on account of their being often extended over a wide and varying range of solar longitude In our procedure we have simply adopted d Azambuja s law as the best available one and one which has been determined quite distinctly apart from its suitability to any preconception of what would suit any particular theory

KODAIKANAL OBSERVATORY

11th February 1937

T ROYDS

M SALARUDDIN

GIPD 11 D K I Observatory 10 5 37 —430

Kodaikanal Observatory.

BULLETIN No. CXII. 112

SUMMARY OF PROMINENCE OBSERVATIONS FOR THE FIRST HALF OF THE YEAR 1936.

In pursuance of the programme of work adopted since 1st January 1923 under the auspices of the International Astronomical Union all observatories taking spectroheliograms of the sun have been asked to co-operate with the Kodaikanal Observatory by supplying copies of their photographs for the days when the Kodaikanal records are imperfect or wanting. In response to our requirements for the first half of the year 1936, the Mount Wilson Observatory supplied Calcium (K_{232}) prominence plates for 18 days and Hα disc plates for 10 days, the Meudon Observatory supplied Calcium (K_3) disc plates for 5 days and Hα disc plates for 18 days, the Ewhurst Observatory (Mr. J. Evershed's) supplied Hα prominence plates for 2 days and Hα disc plates for 3 days and the Solar Physics Observatory, Cambridge, supplied Calcium prominence plates for 4 days.

When only incomplete or imperfect photographs for any day are available from more than one observatory, the best photograph is chosen as representing the solar activity of that day, after weighting it according to its quality, and the remaining photographs are ignored.

Calcium Prominences at the Limb.—The mean daily areas and numbers of prominences photographed during the half-year by means of the K line of Calcium are given below. The means are corrected for incomplete or imperfect observations the total of 181 days for which plates were available being reduced to 164 effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North	3·35	6·95
South	3·57	7·09
Total	6·92	14·04

Compared with the previous half-year, areas show an increase of 29 per cent and numbers an increase of 3 per cent. The increase in areas is slightly more in the southern hemisphere than in the northern.

For comparison with bulletins issued prior to the co-operation of other observatories the means based on Kodaikanal photographs alone are also given, 159 days of observation being counted as 149 effective days.

	Mean daily areas (square minutes).	Mean daily numbers.
North (Kodaikanal photographs only)	3·43	6·91
South (do.)	3·57	7·04
Total	7·00	13·95

The distribution of prominences in latitude is represented in the following diagram, in which the full line gives the mean daily areas and the broken line the mean daily numbers for each zone of 5° of latitude. The ordinates represent tenths of a square minute of arc for the full line and numbers for the broken line. Compared with the previous half year, the zone of maximum activity has advanced 10° towards the pole in the northern

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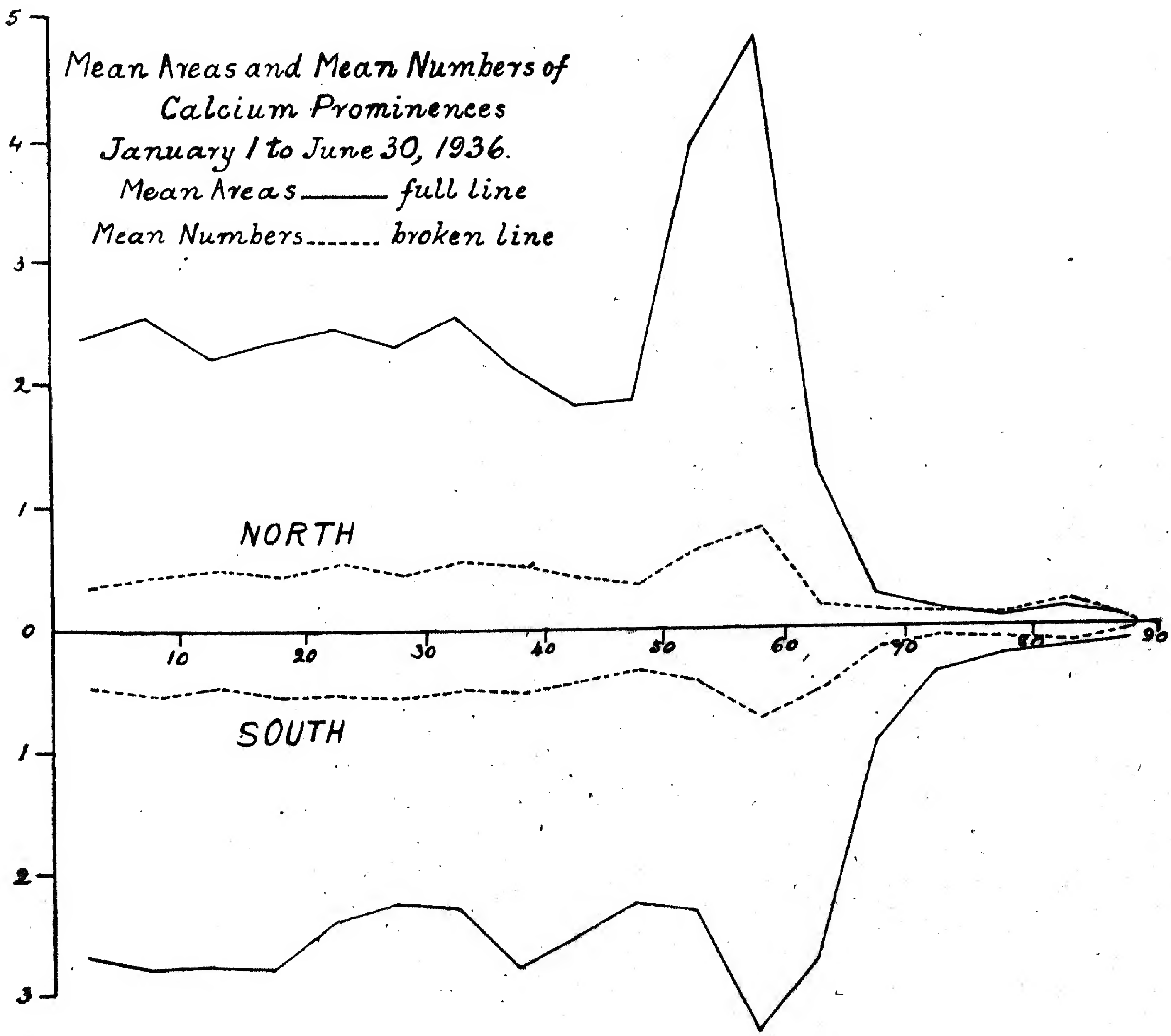
hemisphere and only 5° in the southern. In the southern hemisphere the distribution in areas is more uniform than in the previous half-year.



The monthly, quarterly and half-yearly areas and numbers, and the mean height and the mean extent of the prominences on photographs from all co-operating observatories are given in Table I. The unit of area is one square minute of arc. The mean height is derived by adding together the greatest heights reached by individual prominences and dividing by the total number of prominences observed, and the mean extent is derived

by adding together the lengths of the base on the chromosphere of individual prominences and dividing by the total number of prominences.

TABLE I.—ABSTRACT FOR THE FIRST HALF OF 1936.

Months.	Number of days (effective).	Areas.	Numbers.	Daily means.		Mean height.	Mean extent.
				Areas.	Numbers.		
1936.						"	°
January	28½	208·7	371	7·26	12·90	41·40	8·58
February . . .	28	191·1	391	6·82	13·96	41·29	7·57
March	27½	169·4	424	6·03	15·10	43·55	7·12
April	29	209·7	369	7·23	12·72	45·43	8·66
May	27	212·2	385	7·86	14·26	43·90	7·88
June	23½	143·0	362	6·09	15·40	36·45	6·23
First quarter . . .	84½	569·2	1,186	6·74	14·04	42·13	7·73
Second quarter . . .	79½	564·9	1,116	7·11	14·04	41·99	7·60
First half-year . . .	164	1134·1	2,302	6·91	14·04	42·06	7·67

Distribution East and West of the Sun's Axis.

Both areas and numbers show a defect at the east limb as will be seen from the following table :—

January to June 1936.	East.	West.	Percentage East.
Total number observed	1134	1168	49·26
Total areas in square [illegible]	558·6	573·5	49·34

Metallic Prominences.

Thirty seven metallic prominences were observed during the half-year and their details are given below :—

TABLE II.—LIST OF METALLIC PROMINENCES.—JANUARY TO JUNE 1936.

Date.		Time I. S. T.		Base.	Latitude. North.	Latitude. South.	Limb.	Height.	Lines. (See note at end of table).
		H.	M.	°	°	°		″	
1936. January	1	10	34	2	29		E	10	4, 10, 11 and 12.
	2	10	15			54	E	10	4 and 10.
		10	15			58	E	10	4 and 10.
		10	15			60	E	10	4 and 10.
	10	8	56	2		10	W	20	4 and 10.
	25	9	14	5		29·5	W	20	1, 2, 4, 9, 10, 11 and 12.
	26	9	45	7		32·5	W	25	4 and 10.
		9	56	7		32·5	W	35	1, 2, 4, 9, 10, 11 and 12.
	27	9	17	4		33	W	15	1, 2, 4, 9, 10, 11 and 12.
	28	9	14	4		33	W	20	4 and 10.
	30	9	42	6	30		E	30	1, 2, 4, 9, 10, 11 and 12.
February	6	10	26	5		27·5	E	30	1, 3, 4, 9, 10, 11 and 12.
	7	10	19	4		27	E	30	1, 2, 3, 4, 5, 6, 8, 9, 10, 11 and 12.
	8	10	5	5		28·5	E	20	1, 3, 4, 9, 10, 11 and 12.
	10	9	15	1	6·5		W	25	1, 2, 4, 9, 10, 11 and 12.
	15	9	30	4		22	W	25	4 and 10.
		9	50	4		17	E	15	1, 3, 4, 9, 10, 11 and 12.
	16	10	25	2	19		E	20	4 and 10.
	19	9	35	3	21·5		W	15	1, 2, 4, 9, 10, 11 and 12.
	22	10	30			30	W	10	4, 10, 11 and 12.
March	1	9	23	4		31·5	W	20	1, 3, 4, 9, 10, 11 and 12.
	13	11	0	1		19·5	W	10	4 and 10.
	15	8	49	4		24	E	15	4 and 10.
	19	9	55	4		14	E	20	1, 2, 4, 9, 10, 11 and 12.
	23	8	52	2		30	W	15	1, 2, 4, 9, 10, 11 and 12.
	24	8	52	1		29·5	W	25	4 and 10.
		8	45	1		16·5	W	20	1, 2, 3, 4, 9, 10, 11 and 12.
		8	43	3	12·5		W	10	4 and 10.
	26	9	35	1		22	E	15	1, 2, 4, 9, 10, 11 and 12.
		9	13	4	22		W	20	1, 2, 3, 4, 9, 10, 11, 12 and line 5371·7.
April	3	9	25	2		15	W	20	1, 2, 3, 4, 6, 7, 8, 9, 10, 11 and 12.

Date.		Time I. S. T.		Base	Latitude.		Limb.	Height.	Lines. (See note at end of table.)
					North.	South.			
		H.	M.	°	°	°	′	″	
1936. April	7	9	18	3	18·5		E	20	1, 2, 3, 4, 5, 6, 8, 9, 10, 11 and 12.
	15	9	23	1		18·5	E	15	1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12 and lines 5197·8, 5208·7, 5269·7, 5270·5, 5284·3, 5324·3, 5328·2, 5337·0, 5371·7, 5397·3.
	16	10	10	10		17	E	15	1, 2, 3, 4, 8, 9, 10, 11 and 12.
	18	10	30		14		W	10	1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12 and lines 5197·8, 5227·4, 5269·7, 5270·5, 5284·3, 5324·3, 5328·2, 5371·7, 5397·3, 5406·0, 5424·8, 5430.
May	4	9	15	3		22·5	E	20	1, 2, 3, 4, 9, 10, 11 and 12.
	10	10	8	4		26·0	E	15	4 and 10.
June	11	11	6	3		21·5	W	15	1, 2, 3, 4, 9, 10, 11, 12 and line 5328·2.

NOTE.—The key to the wave-lengths of metallic lines is as follows :—

No.	λ	Element.	No	λ	Element.
1	4924·1	Fe+	7	5276·2	Fe+
2	5016·9	He	8	5316·8	Fe+
3	5018·6	Fe	9	5363·0	Fe+
4	b_4, b_3, b_2, b_1	Mg. Fe+	10	D_2, D_1	Na
5	5234·8	Fe	11	6677	He
6	5276·0	Cr	12	7065	He

The distribution of metallic prominences was as follows :—

	1°—10°.	11°—20°.	21°—30°.	31°—40°.	41°—50°.	51°—60°.	Mean latitude.	Extreme latitudes.
North . .	1	4	4	..	..	..	19°·2	6°·5 and 30°.
South . .	1	6	14	4	..	3	27°·8	10° and 60°.

Eighteen were on the east limb and 19 on the west limb.

Displacements of the Hydrogen Line

Particulars of displacements observed in the chromosphere and prominences with the spectroscope are given n the following table —

TABLE III —DISPLACEMENTS OF THE HYDROGEN LINE JANUARY TO JUNE 1936.

Date		H u IST		Lat tud		Limb	Displacement			Remarks.
				N rth	S uth		Red	Violet	Both ways	
		H	M				A	A	A	
1936										
J nua y	2	10	39	23		E		Slight		At top
		10	24		3	E	Slight			In chromosphere
		10	15		55	E		1		At top.
	3	11	12		87	E		1		In chromosphere
	4	9	14		50	E	0 5			At base
		9	30		15	W	1			At top
		9	30		21	W		1		At base
		9	30		25	W		1		Do
	5	9	25		13	W	1 5			At top extends from −12° to −14
	6	9	30	15 5		E	1 5			At top
		9	20		37 5	W		0 5		At base
		9	14		15 5	W	1 5			At top
	7	8	50		46 5	W		Slight		At base extends from −45 to −48°
		8	50		43	W	Slight			At top.
		8	45		17 5	W		0 5		At base
	8	10	17		50	W		1		At top.
	9	9	30		78	E			1	At base.
		9	10		7 5	W	0 5			At top
	10	9	0		3 5	W	0 5			At middle of prominence extends (from −2° to −5°)
		9	0		4	W	0 5			At middle of prominence.
		9	0		7 5	W			1	At base ; extends from −6° to −9°
		9	0		4	W		0 5		At middle of prominence, extends from −3° to −5°
	17	9	10	41		W		Slight		In chromosphere
	18	10	0		27 5	E	1			At base
		10	0		33 5	E	1			At top ; extends from −32° to −35
		10	34	82		W	1			At top
	2	11	23	50 5		E	Slight			At top
		11	36	19 5		W		3		In chromosphere.
		11	38	20		W	2			At top
	23	9	14		16 5	W	0 5			At top ; extends from −15° to −18°
	24	9	22	11		E	Slight			In chromosphere.
		9	24		4	E		0 5		At top extends from −2° to −6°
		9	15		32	W	1 5			At top
		8	57	22		W	1			At base.
	25	9	40	8		E	Slight			In chromosphere.
		9	15		33	W	1	0 5		At top ; extends from −32° to −34°
		9	7	25		W		0 5		At top ; extends from +23° to +27°
		9	0	72 5		W	Slight			At base
	26	9	18	82		E	0 5			At top.
		9	43		44 5	W		0 5		At base ; extends from −43° 5 to −45° 5.
		9	40		30 5	W			1	At base ; extends from −29° to −32°
	27	9	30		67 5	E		1		At top
		9	20		38 5	W		1 5		At base.
		9	17		33	W			0 5	Do
		9	8		21 5	W	1 5			At top extends from −20° to −23°
		9	0	28		W	1			At top
	28	9	32		26	E	Slight			At base.

Date.	Hour I. S. T.		Latitude.		Limb.	Displacement.			Remarks.
			North.	South.		Red.	Violet.	Both ways.	
	H.	M.	°	°		A	A	A	
1936. January 28—contd.	9	16		36	W	1·5			At top; extends from —34° to —38°.
	9	15		33	W	1			At top.
	9	14		23·5	W	1			Do.
	9	2	57·5		W		1		Do.; extends from + 56·5° to +58·5°.
29	9	18		24	W	1			Do.; extends from —23° to —25°.
	9	10	21		W	0·5	2		To Red at base to violet at top; extends from +20° to +22°.
	9	8	29		W		0·5		At top; extends from +27° to +31°.
30	9	37	37		E	2·5			At base.
	9	35	22		E		1·5		Do.
	9	34		44·5	W	1			At top; extends from —42·5° to —46·5°.
	9	22		36	W			1	At base; extends from —35° to —37°.
	9	22		32	W	1			At top.
	9	15	4		W		1		At base.
	9	10	26		W	0·5			At top; extends from +24° to +28°.
	9	8	28·5		W		0·5		At middle.
	9	4	40·5		W	1			At top; extends from +39°·5 to +41°·5.
	9	3	48·5		W	Slight			In chromosphere.
31	10	19	38		E		1		At top.
February 1	9	4		79	W		1		At top.
	9	0		28	W		1		Do.
5	11	9	52		E	1			Do.; extends from +50°·5 to +53°·5.
	10	56		23	E	1			Do.
	10	56		27	E	1			At base.
6	10	18		16	E		0·5		At top.
	10	19		21·5	E	1			Do.
	10	26		27·5	E			1	At base; extends from —25° to —30°.
	10	7		25·5	W	1			At top.
	9	55	66		W	0·5			In chromosphere.
7	10	22		15	E	1·5			Do.
	10	2		29	E		Slight		At top.
	10	2		32·5	E	1			Do.
	10	28		32·5	E		2		Do.
	10	2		38·5	E	2			Do.; extends from—36°·5 to—40°·5
	9	53		83·5	W		1		Do.
8	10	5		28	E	2·5	0·5		To red at top, to violet at base; extends from —26° to —30°.
	9	48	46		W		0·5		At base.
10	8	55	78		E		Slight		Do.
	9	18	2·5		W	2	1		At top; extends from +1° to +4°.
	9	18	5		W	1			Do.; extends from + 4° to +6°.
	9	15	9		W			2	At base; extends from +8° to +10°.
	9	7	12		W	2			At top.
	9	7	18		W		1		In chromosphere; extends from +17° to +19°.
12	10	0		27·5	E	1			At top; extends from —26° to —29°.
	10	36	26·5		W		1		At base.
14	9	17		58·5	E	2			Do.
15	9	48		10	E		Slight		At top; extends from —8° to —12°.
	9	50		17	E			1	
	9	32		26·5	W		0·5		At top.
	9	32		25·5	W		2·5		At base.
	9	29		15	W	0·5			At top; extends from —13° to —17°.

Date		H I S T		Latitude North	Latitude South	Limb	Displacement Red	Displacement Violet	Displacement Both ways	Remarks.
		H	M				A	A	A	
1936 February 15—contd		9	24	37		W	0 5			At top extends from +35° 5 to +39 5
	16	10	5	10		E			1	At base extends from +18 to +20°
		10	8	14		E	0			In chromosphere
		10	30		18	E		0		At top
		10	10		31	W	0 5			Do extends from —29° 5 to —32 5
	17	9	6	7		E	0 5			Do extends from +25 to +29
	18	8	44	17		E	Slight			At top
		8	54	31		W	Slight	Slight		Red at top violet at base
		8	58	38 5		W		0 5		At base
		8	0	34 5		W	Slight	Slight		To red at top to violet at base
	19	9	55		82	W	Slight			In chromosphere
		9	41		1	W	0 5			At top
		9	3	19		W	5			Do extends from +18 to +20°
		9	30	41		W		1 5		Do
		10	3		2	E		1		Do
	27	9	7	23 5		E			0 5	At base extends from + 22° to +25
		9	31		18	E	1			At top
		9	15		61 5	W	1 5			Do extends from —59° to —64
		9	5		60 5	W		4		Do ; extends from —59° to —62°
		9	40		57 5	W	2			Do extends from —55 5 to —59 5.
		9	55		32	W	1 5			Do extends from —29° 5 to —34 5
		8	52		17	W		0 5		Do
	8	9	12		39	W	Slight			Do
		9	5		20 5	W	0 5			Do
	29	9	30		35 5	W		Slight		At base.
		9	46	8		W	4			At top
		9	46	8 5		W		4		At base.
		9	46	14		W		2		At base
		10	4	44 5		W		1		In chromosphere.
March	1	9	17	14		W	Slight			At top ; extends from +13° to +15°
		9	1	8		W		Slight		Do
	2	9	0	66 5		E		1		In chromosphere.
		9	3		45 5	E	Slight			Do
		9	12	22		W		1		At top.
		9	12	27		W		0 5		Do.
		9	5	44 5		E	Slight			At top
	4	9	3	32 5		E	Slight			At base
		9	12		15	W		1		In chromosphere
	6	11	22		15	W		1		At top extends from—14° to—16°
		11	37	54 5		W	1			At middle
		11	37	60 5		W	1			At top
	7	9	9		21 5	F		0 5		At top extends from —19° to —24
		9	0		30	E	1			Do extends from —29° to —32°
	8	8	31	70		E	0 5			Do
	9	9	47		30 5	F	1			Do ; extends from —29° 5 to —31 5
									0 5	
	13	11	0		19 5	W				At base.
		10	5		23	W		0 5		At top.
	14	9	48	8 5		E	1			Do
		9	29		18	E		Slight		Do.
		9	29		19	E		Slight		Do
		9	29		8	E		1		At middle extends from —24 to —26°
	1	8	49		25	E		Slight		In chromosphere
	16	9	3	15		E	Slight			At top ; extends from —14° to —17
		9	6		15 5	W	0 5			

Date.		Hour I. S. T.		Latitude.		Limb.	Displacement.			Remarks.
				North.	South.		Red.	Violet.	Both ways.	
		H.	M.	°	°		A	A	A	
1936. March *contd.*	16—	9	1	37		W	0·5			At top ; extends from—14° to—17°.
		8	58	73·5		W		Slight		In chromosphere.
	19	9	55		15	E	2·5			At base ; extends from —14° to —16°.
		9	40		26	W		1·5		Do. ; extends from —24° to —28°.
	21	9	15		28	E	Slight			At top.
	22	9	40	30		W	1			Do.
	23	9	15		28	E	1			Do.
		9	16		37·5	E		1		Do.
		8	52		30	W		1·5		Do. ; extends from —21° to —31°.
		8	50		22·5	W	2	3		To red at base, to violet at top ; extends from — 19° to —26°.
	24	8	31	21		E		1		At base ; extends from +19° to +23°.
		8	52		34	W		1		At top ; extends from—32°·5 to —35°·5.
		8	45		16·5	W		1·5		At base.
		8	43	14		W		0·5		Do.
	25	9	5	20		E	1			Do.
		9	5	21		E		1		At top.
		9	14		41·5	W		1		At base.
		9	29		26	W		1		In chromosphere.
	26	8	57	70·5		E	0·5			At top.
		9	33		8·5	E	1·5			Do. ; extends from —7° to —10°.
		9	35		22	E	0·5			At base ; extends from —21° to —23°.
		9	40		30	E	1·5			At top.
		9	22		34	W	0·5			At top ; extends from —32·5° to —35·5°.
		9	15	12		W	1			At base ; extends from +11° to +13°.
		9	13	22		W			1	At base; extends from +20° to +24°.
	27	9	33	30		E	0·5			At top.
		10	0	26		E		0·5		Do. ; extends from +25° to +27°.
		10	15	22		E		0·5		At base; extends from +21° to +23°.
April	2	10	0	23		E	1			In chromosphere.
		10	7		23	W		1		Do.
		10	16	6		W	1			At top.
	3	8	55	51·5		E		1		Do. ; extends from +50°·5 to +52°·5.
		8	55	45		E		0·5		At base.
		8	55	43·5		E		1		At top ; extends from +40°·5 to +46°·5.
		9	25		20	W	Slight			At base.
	7	11	10	42·5		E		0·5		At top ; extends from +41°·5 to 43°·5.
		9	18	18·5		E		1		Do. ; extends from +17° to +20°.
		9	39		13	E	0·5			At base.
	8	9	16	22		E	0·5			Do.
		9	5	14		W	1			At top.
		9	5	19		W	1·5			Do.
	11	8	37		38	W		0·5		Do.
		8	34		29	W	0·5			Do. ; extends from —28° to —30°.
		8	29	16		W		Slight		At base.
	12	9	27	27		E	1			At top.
		9	24		21	E		1		Do.
		10	51	36		W			Slight	Do.
	14	9	25	29		W	1			Do.
		9	25	34		W	1			Do.
	15	9	12		12	E		1		Do.
		9	23		18·5	E		2		Do.
		9	12		26	E	0·5			At base.
		10	30	16·5		W	1			At top ; extends from +15° to +18°.

Date	H M I S T	Latitude North	Latitude South	Limb	Displacement Red	Displacement Violet	Displacement Both ways.	Remarks.
	H M				A	A	A	
1936 April 15—*contd*	10 32	3 5	10	W		1		At top.
16	10 2		60 5	E	2	1 5		At middle
	9 42		28	W	1 5			At base
	9 36		5 5	W	0 5			At top
	9 32			W	0 5			Do.
19	8 55	8 5		W	Slight			At top; extends from +7° to +10°
	8 55	13		W	2	1 5		To red at top, to violet at base extends from +12° to +14°
	8 47	36 5		W		1		At base
21	9 12		3	E	Slight			Do.
	9 7		28	W		0 5		Do
23	9 2	52 5		E		0 5		At top.
	9 20		38	W	0 5			Do ; extends from —37° to —39°
	9 19		26	W			1	Do extends from —25° to —27°.
	9 17		18	W	0 5			Do extends from —17° to —19°
4	8 50	34 5		E		0 5		At middle ; extends from +32° to +37°
29	10 55	3		W		1		At base.
30	9 30	13		E	1	0 5		Do. ; extends from +12° to +14°
	9 32		4 5	E	1			At top ; extends from —3° to —6°
	9 18		38 5	W	1			Do. extends from —35° to —42°
	9 7	83 5		W		Slight		In chromosphere.
May 1	9 7		24	E		Slight		At top
	9 34		43	W	1			Do
	9 34		52	W	1			Do
	9 35		36	W	1			Do
2	9 27	22		E	1			Do extends from +20° to +24°.
4	9 0		12	E		0 5		At base extends from —10° to —14
	9 15		20	E	1			At top
7	9 10		29 5	E		1		At base
8	9 22	26		W			Slight	Extends from +25° to +27°.
10	10 8		24	E		0 5		At top ; extends from —23° to—25°.
	10 3		17	W	0 5	0 5		To red at top, to violet at base.
11	9 16		27	E		0 5		At top extends from —26° to —28
	9 20		42 5	E	0 5			At base extends from —41° to —44°
	8 50	36		W	4			At middle ; extends from +34° to +38°
	8 50	39 5		W			2	At top ; extends from +38° to +41°
	8 50	43 5		W		3 5		Do. ; extends from +41° to +46°.
13	9 20	10		E		1		Do.
	9 18		13 5	E	1			Do. ; extends from —12° to —15°.
	9 18		19	E	1			At base.
14	8 57	17		W	1			At top ; extends from +16° to +18°.
	8 57	20		W		0·5		At base.
29	10 7	16		E	1			At top ; extends from +15° to +17°.
	10 15		15	W			Slight	
30	9 34	41		E	1	2		At base.
	9 20		39	E	Slight			Do. ; extends from —38° to —40°.
	9 20		41	E		Slight		At top ; extends from —40° to —42°.
	9 10		48	E	1			At middle, extends from —46° to —50°.

Date.	Hour I. S. T.		Latitude.		Limb.	Displacement.			Remarks.
			North.	South.		Red.	Violet.	Both ways.	
	H.	M.	°	°		A	A	A	
1936. May 30—*contd.*	9	46	11		W		2		At base.
31	9	15	11·5		W		1		Do.
June 5	9	8	55·5		W		0·5		At top; extends from +53° to +58°.
6	9	10		17	W	2			
	9	11		14·5	W	1			At top.
11	11	7		21	W	1·5			At base; extends from —20° to —22°.
	11	7		23	W	2			At top.
	11	8		29	W		1		Do.; extends from —28° to —30°.
13	10	50	18		E		Slight		Do.
19	9	15		13	E		Slight		Do.
21	9	10		15	W		1		At base.

The total number of displacements was 274 as against 83 in the previous half-year and their distribution was as follows :—

		North.	South.
1°—30°		72	100
31°—60°		38	44
61°—90°		11	9
	Total	121	153
East limb		..	114
West limb		..	160
	Total	..	274

Of these displacements, 140 were towards the red, 117 towards the violet and 17 both ways simultaneously.

Reversals and Displacements on the Sun's Disc.

Four hundred and forty-one bright reversals of the Hα line 416 dark reversals of the D_3 line and 72 displacements of the Hα line were observed with the spectroscope during the half-year. Their distribution is given below :—

	North.	South.	East.	West.
Bright reversals of Hα	173	268	209	232
Dark reversals of D_3	162	254	192	224
Displacements of Hα	30	42	27	45

Thirty-seven displacements were towards the red, 13 towards the violet and 22 both ways simultaneously.

The Hale spectroheliosope has been used daily (except on Sundays and holidays) for the observation in the light of the Hα line of changing phenomena and of displacements which cannot be readily photographed. The hours allotted by the International Astronomical Union to this observatory for spectrohelioscope observations are 2-30 to 3-00, 4-00 to 4-30, 5-30 to 6-00, and 6-30 to 7-00 G. M. T. or 8-00 to 8-30, 9-30 to 10-00, 11-00 to

-30 and 12-00 to 12-30 I. S. T., but observations are continued at other times in cases where interesting developments are likely to occur. A summary of the observations made during the first half of 1936 is given below :—

	East limb.	West limb.	Total.
Displacements in prominences	62	36	98

	North.	South.	East.	West.	Total.
Displacements in Hα dark markings	18	21	21	18	39
Displacements in Hα bright flocculi	2	5	1	6	7

	Displacements towards Red.	Violet.	Both ways.	Total.
Prominences	54	44	..	98
Hα dark markings	26	11	2	39
Hα bright flocculi	2	4	1	7

Prominences Projected on the Disc as Absorption Markings.

Photographs of the sun's disc in Hα light were available from Kodaikanal and the co-operating observatories for a total of 181 days which were counted as 175 effective days. The mean daily areas of Hα absorption markings (corrected for foreshortening) in millionths of the sun's visible hemisphere and their mean daily numbers are given below :—

	Mean daily areas.	Mean daily numbers.
North	4343	19·66
South	5197	25·01
Total	9540	44·67

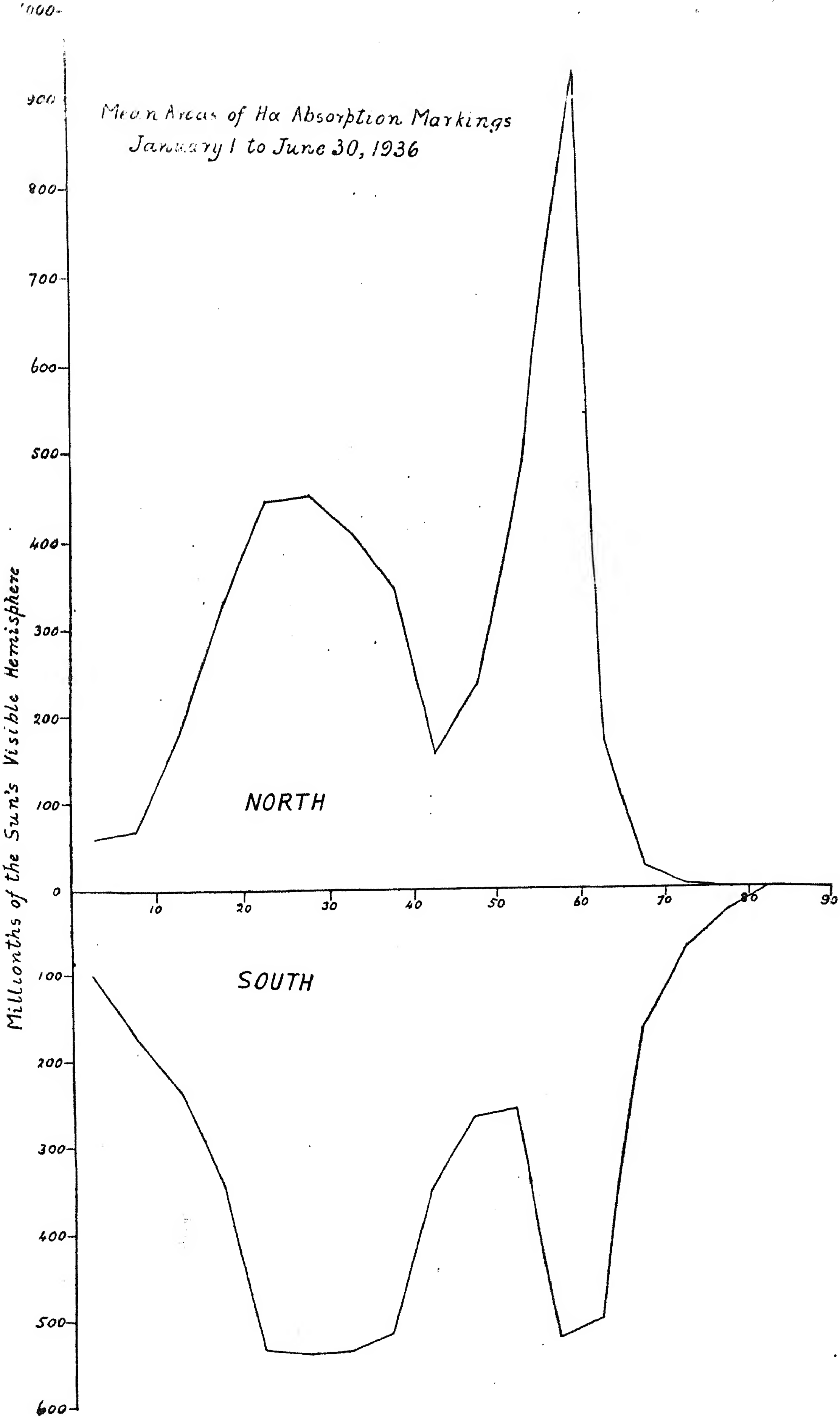
The above show an increase of 74 per cent in areas and 61 per cent in numbers, compared with the previous half-year.

For comparison with bulletins issued prior to the co-operation of other observatories the means based on Kodaikanal photographs alone are also given, 151 days of observation being reduced to 149 effective days.

	Mean daily areas.	Mean daily numbers.
North (Kodaikanal photographs only)	4354	19·36
South (do.)	4956	25·17
Total	9310	44·53

The distribution of mean daily areas in latitude is shown in the following diagram. Compared with the previous half-year the zone of maximum activity has advanced 5° towards the poles in both the hemispheres.

The [illegible] in both the hemispheres in the previous half-year remains almost unchanged in position but that in the southern hemisphere has become more significant.



Compared with the previous half-year both areas and numbers show a slight eastern defect, the percentage in areas being 49·14 and in numbers 49·92.

The mean daily areas of Hα absorption markings uncorrected for foreshortening are given below :—

	Mean daily areas.
North	2181
South	2830
Total	5011

The uncorrected areas amount to 53 per cent of the corrected ones. The curve of distribution in latitude is similar to that of the corrected areas as usual.

Thanks are due to the co-operating observatories for the photographs supplied by them.

A. L. NARAYAN,
Director, Kodaikanal Observatory.

KODAIKANAL,
The 2nd May, 1937.

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